Barnes Creek

Louisiana Department of Environmental Quality
Watershed Segment 030601 and 030602

Watershed Implementation Plan

Dissolved Oxygen

Nonpoint Source Unit

EXECUTIVE SUMMARY

To meet the 70% reduction in man-made nonpoint loading in Barnes Creek Watershed as required by the TMDL, a concerted effort by residents, developers, agricultural producers, foresters, and government in the watershed is needed. Specifically, a high priority should be given to implementing agriculture, forestry, and construction BMPs.

In subsegment 030601, the upper reaches of Barnes Creek, pasture/grazing is fairly intensive and the riparian buffer system has been all but removed. AnnAGNPS model results suggest nonpoint loading in this area may be significant, and it seems a rational conclusion that reaches 1 and 2 of Barnes Creek is an area where the implementation of BMPs should be focused.

In subsegment 030602, the lower reaches of Barnes Creek Watershed, implementing forestry BMPs should be a high priority since forestry is the dominant land use. Forestry land bordering the main channel of Barnes Creek is a priority. Care should be taken to preserve the intact riparian buffer system of bottomland hardwoods that exists in the lower reaches of Barnes Creek Watershed.

A consolidated list of recommended BMPs can be found in the State of Louisiana Water Quality Management Plan, Volume 6, *Louisiana's Nonpoint Source Management*, 2000.

1.0 INTRODUCTION

Nonpoint source pollution is a diffuse source of water pollution that flows across land transporting contaminants to a waterbody. Common land-use categories that contribute to water quality impairments from nonpoint sources of pollution include agriculture, forestry, urban runoff, construction, home sewerage systems, resource extraction, and hydromodification. Detailed explanations of each category can be found in the State of Louisiana Water Quality Management Plan, Volume 6, *Louisiana's Nonpoint Source Management*, 2000.

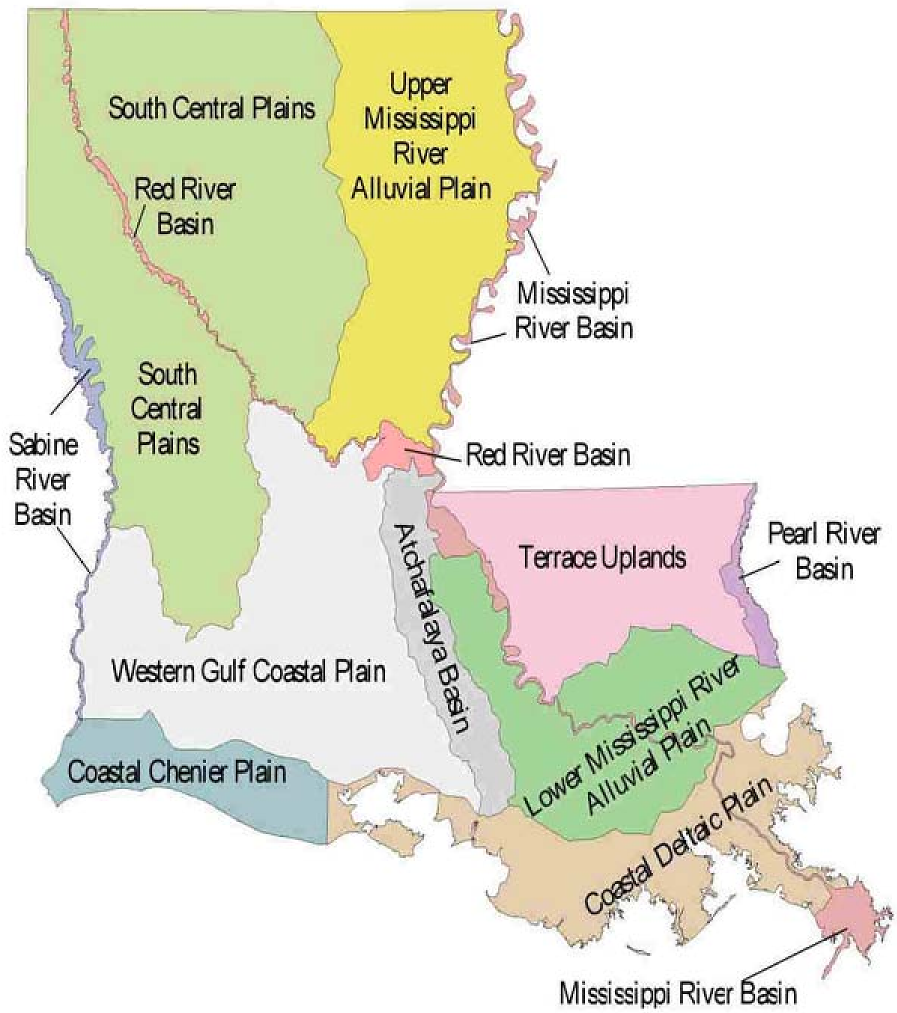
Section 319 of the Clean Water Act authorizes The Environmental Protection Agency (EPA) to issue grants to states to assist in implementing management programs to control nonpoint sources of water pollution. Highest priority is to be given to waterbodies included in the 303(d) List of Impaired Waters. A waterbody is entered into the 303(d) list when it surpasses the water quality standard 10% of the time during an assessment period. Barnes Creek Watershed (subsegments 030601 and 030602) was found to not be meeting its designated use of Fish and Wildlife Propagation based on 1999 ambient sampling data and a Total Maximum Daily Load (TMDL) for oxygen-demand pollutants has been developed. The purpose of this report is to outline a plan, which can be implemented with federal, state, and local funds, to reduce the amount of nonpoint source pollution entering Barnes Creek and thereby increasing water quality to a level where the waterbody fully meets designated uses.

1.1 ECOREGION DESCRIPTION

Barnes Creek Watershed extends from the South Central Plains into the Gulf Coastal Plain Ecoregions (figure 1). The South Central Plain Ecoregion includes the longleaf pine forests, maximum elevations and relief, dendritic and trellis drainage, interior salt domes, wolds or cuestas (hard sedimentary rock), ironstone, excellent surface and groundwater resources, mature soils and the oldest rocks in the state. The soil types consist of coastal plain soils and flatwoods soils. Vegetation includes longleaf pine forests (longleaf pines, slash pines, some hardwoods) and bottomland hardwoods (cottonwood, sycamore, willow, water oaks, gum, maple, loblolly pine). (Kniffen, 1988)

The Gulf Coastal Plain Ecoregion includes intermediate elevations and relief, older alluvium, and a large percentage of tabular surfaces. The terraces range from flatwoods to prairies. The flatwoods consist of low relief, mixed longleaf forests, bagols, pimple mounds, dendritic drainage, and flatwoods soils. Vegetation includes flatwoods (longleaf pine, oak, palmetto, wiregrass), cypress forests (cypress, tupelo), and bottomland hardwoods. The prairies consist of low relief, prairie grassland, prairie soils, pimple mounds, dendritic streams, ice-age channels, and platin or marais (small, shallow undrained ponds in the prairies). Vegetative cover consists of prairie vegetation (bluestem, broomsedge), cypress forests, and bottomland hardwoods (Kniffen, 1988)

Figure 1. Map of Louisiana Ecoregions.



1.2 CALCASIEU BASIN DESCRIPTION

The Calcasieu River Basin is located in southwest Louisiana and is positioned in a north-south direction between the Mermentau and Sabine Rivers. The drainage area of the Calcasieu Basin comprises approximately 3,910 square miles. Headwaters of the Calcasieu River are in the hills west of Alexandria and the Calcasieu River flows south for about 160 miles to the Gulf of Mexico. The mouth of the river is about 30 miles east of the Texas-Louisiana state line. The landscape in this basin varies from pine-forested hills in the upper end to brackish and salt marshes in the lower reaches around Calcasieu Lake and also includes the city of Lake Charles.

Low slope condition in much of the Calcasieu River Basin may causes many of the streams in the Calcasieu River Basin to be characteristically sluggish. Many of the tributaries to the Calcasieu River, have low flows or become stagnant during critical times of the year. This statement is not accurate for the Calcasieu River itself, which tends to have a significant amount of flow throughout the year. Because many waterbodies in the basin have little gradient and sluggish flows, their reaeration potential is low.

1.3 BARNES CREEK WATERSHED, SUBSEGMENTS 030601 AND 030602

Barnes Creek is a 204.45 square mile watershed in Southwestern Louisiana, in the Calcasieu River Basin. The Barnes Creek watershed system consists of subsegment 030601, which extends from the headwaters near DeRidder to the confluence with Little Barnes Creek, and subsegment 030602,which extends from the confluence with Little Barnes Creek to the confluence with the Calcasieu River (figure 2). The region is sparsely populated, and characterized mainly by agricultural rangelands and forestry. Barnes Creek Watershed includes the following tributaries: Little Barnes Creek, Redhead Branch, Little Caney Creek, Caney Creek, Hurricane Creek, Magnolia Creek, Brushy Creek, Righthand Creek, Boggy Creek, Wolf Creek, Clear Creek, and Bear Creek (figure 3). There are two federal highways, 190 and 171, which traverse the watershed and there are small settlements associated with them. The only major urban area in the watershed is the city of DeRidder, which lies directly to the north of the headwaters. The wastewater treatment plant represents the only point source discharger included in the model.

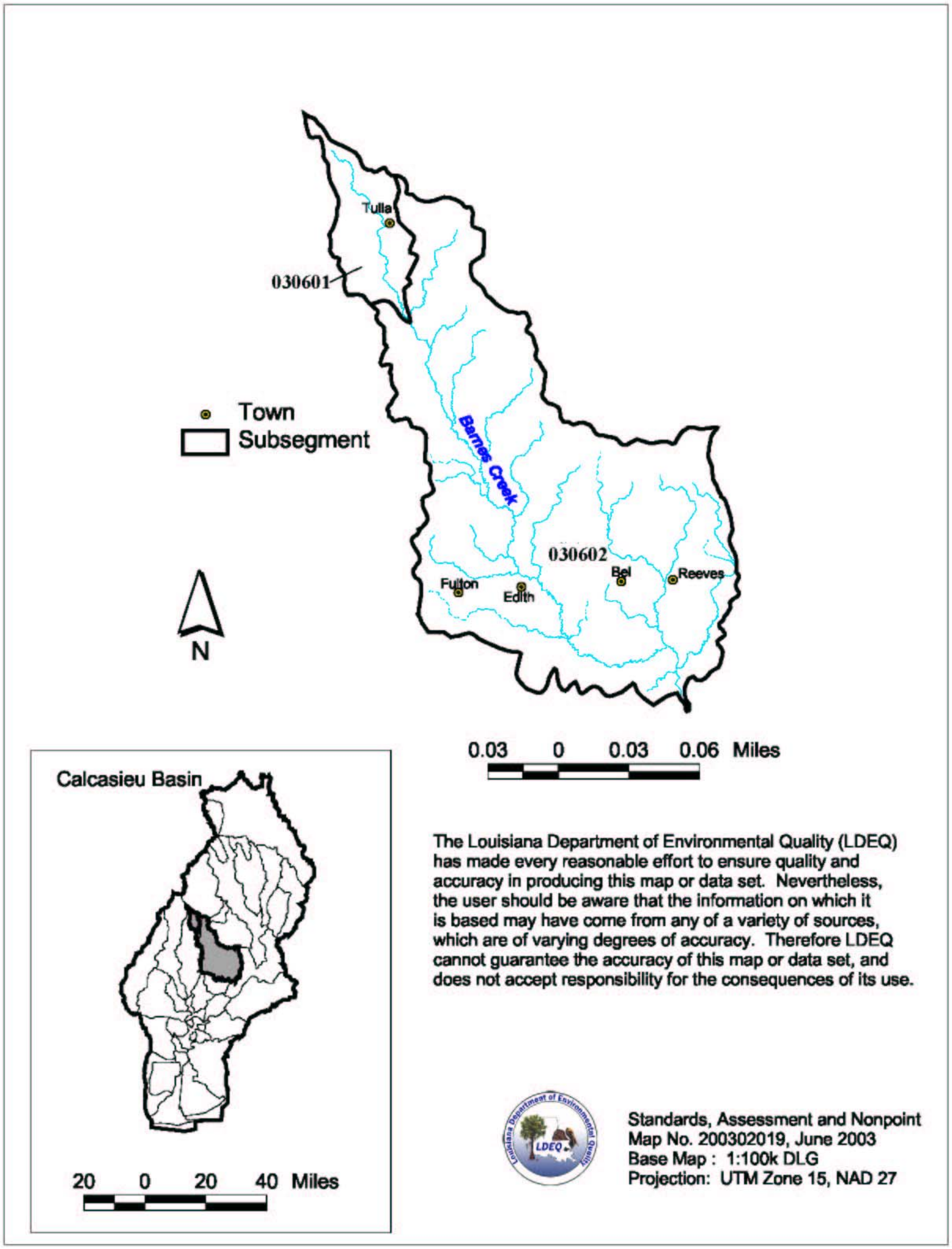


Figure 2. Location of subsegments

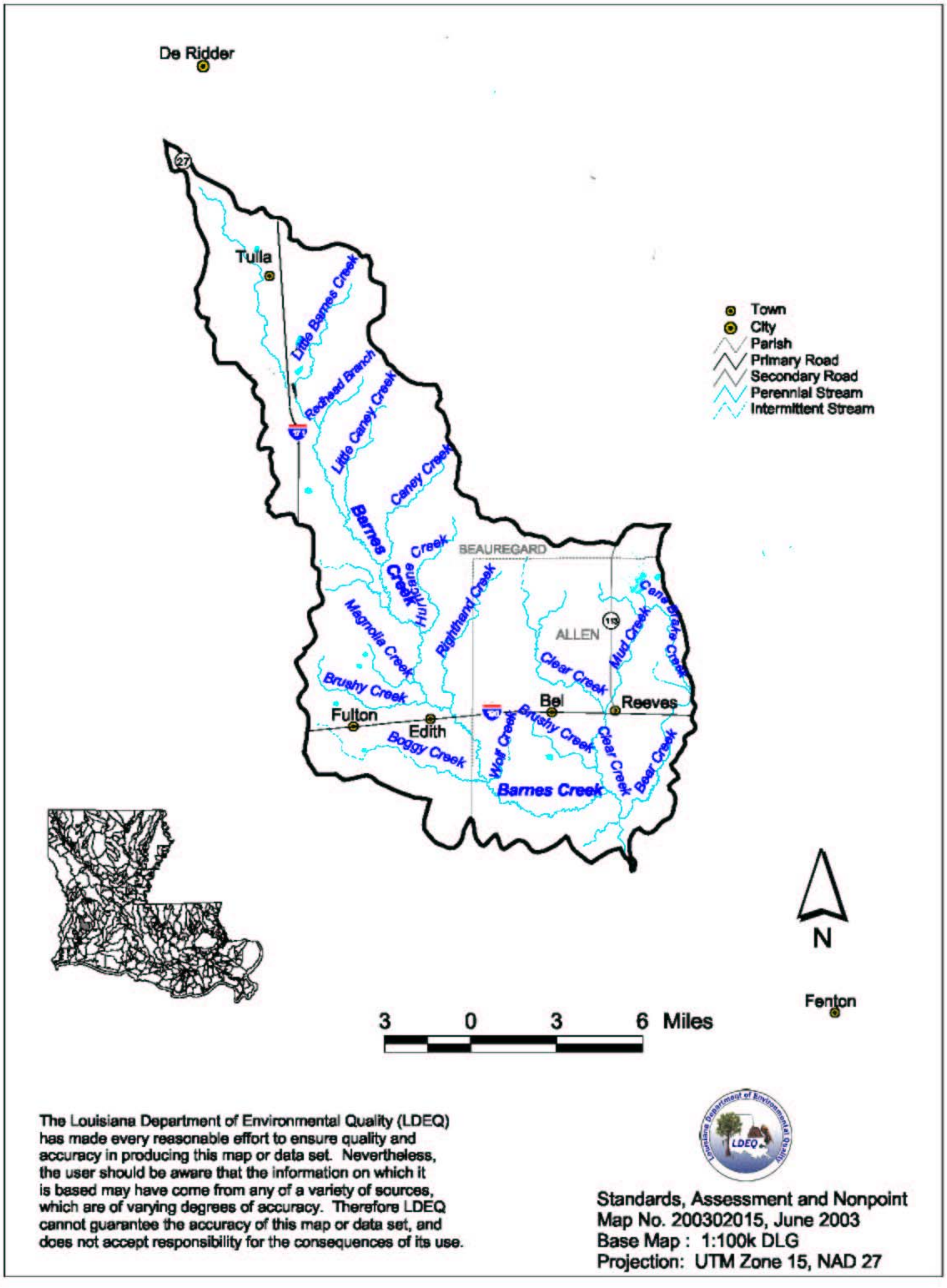


Figure 3 Barnes Creek and Tributaries

1.4 DESIGNATED USES

Subsegment 030601 has two designated uses from November – April, Secondary Contact Recreation and Propagation of Fish and Wildlife. From May – October there are no designated uses. Subsegment 030602 has three designated uses, Primary Contact Recreation, Secondary Contact Recreation, and Fish and Wildlife Propagation (table 1). Primary Contact Recreation refers to fishing and swimming, including full immersion in the water. It is likely that Primary Contract Recreation is not a designated use for subsegment 030601 because of the shallow and intermittent nature of the stream flow in these reaches.

Secondary Contact Recreation includes partial contact with the water, such as wading and boating. Fish and wildlife propagation includes the use of water for preservation and reproduction of aquatic biota such as indigenous species of fish and invertebrates, as well as reptiles, amphibians, and other wildlife associated with the aquatic environment (LDEQ, 2003)

Barnes Creek watershed is listed as meeting its designated uses for primary and secondary recreation, but not supporting fish and wildlife propagation (LDEQ, 2002).

Table 1 .Numerical Criteria and Designated Uses
A - Primary Contact Recreation; B - Secondary Contact Recreation; C - Propagation of Fish and Wildlife; D - Drinking Water Supply; E - Oyster Propagation; F - Agriculture; G - Outstanding Natural Resource Waters; L - Limited Aquatic Life and Wildlife Use

			Criteria						
Code	**Stream Description**	**Designated Uses**	**CL**	**SO_4**	**DO**	**pH**	**BAC**	**°C**	**TDS**
030601	Barnes Creek – Headwaters to entrance of little Barnes Creek	B C	60	60	[2]	6.0-8.5	1	30	150
030602	Barnes Creek – From entrance of Little Barnes Creek to confluence with Calcasieu river.	A B C	60	60	5.0	6.5-8.5	1	32	250

2.0 TMDL FINDINGS

Total Maximum Daily Loads (TMDLs), are the maximum amount of a pollutant that can be discharged into a waterbody without causing the waterbody to become impaired and/or violate state water quality standards. TMDLs are the sum of the individual Wasteload Allocations (WLAs) for point sources, Load Allocations (LAs) for nonpoint and natural background sources, and a Margin of Safety (MOS). The margin of safety is 20% for point sources and 10% for nonpoint sources. The loading for point sources was calculated to be less than 1% of the total loading for the Barnes Creek TMDL model (Figure 4).

TMDL Allocation = WLA + LA + MOS

Barnes Creek was scheduled for TMDL development because it didn't meet water quality criteria for fish and wildlife propagation. The suspected causes of impairment in subsegment 030601 were organic enrichment/low DO and salinity/TDS/chlorides. The suspected sources for 030601 were natural sources and municipal point sources. For subsegment 030602 the suspected cause of impairment was organic enrichment/ low DO. The suspected sources of impairment for subsegment 030602 were natural sources, agriculture, and silviculture. This TMDL implementation plan addresses the organic enrichment/low DO impairment. The sources of TDS were considered to be from unknown / natural sources in 030601, and under the Integrated Reporting system for the 2002 305(b) report TDS was put under category 4(c), that is; currently not scheduled for a TMDL.

It must be noted that since the Barnes Creek is a slow flowing waterbody in a flat plain, conditions tend to be naturally low in oxygen and are often dystrophic. In the development of the model, no one specific reference stream was used, but a composite of different reference streams to represent 'natural' loading conditions.

The largest percentage of the load in Barnes Creek is attributed to nonpoint load (Figure 4). The DO standard for subsegment 030601 is 2.0 mg/l May through October and 5.0 mg/l November - April. Subsegment 030602 has a year round DO standard of 5 mg/l. Projections show that compliance with the current dissolved oxygen criteria will require a 70% reduction of nonpoint loading. The summer TMDL is 3,661 lbs/day and the winter TMDL is 2,939 lbs/day.

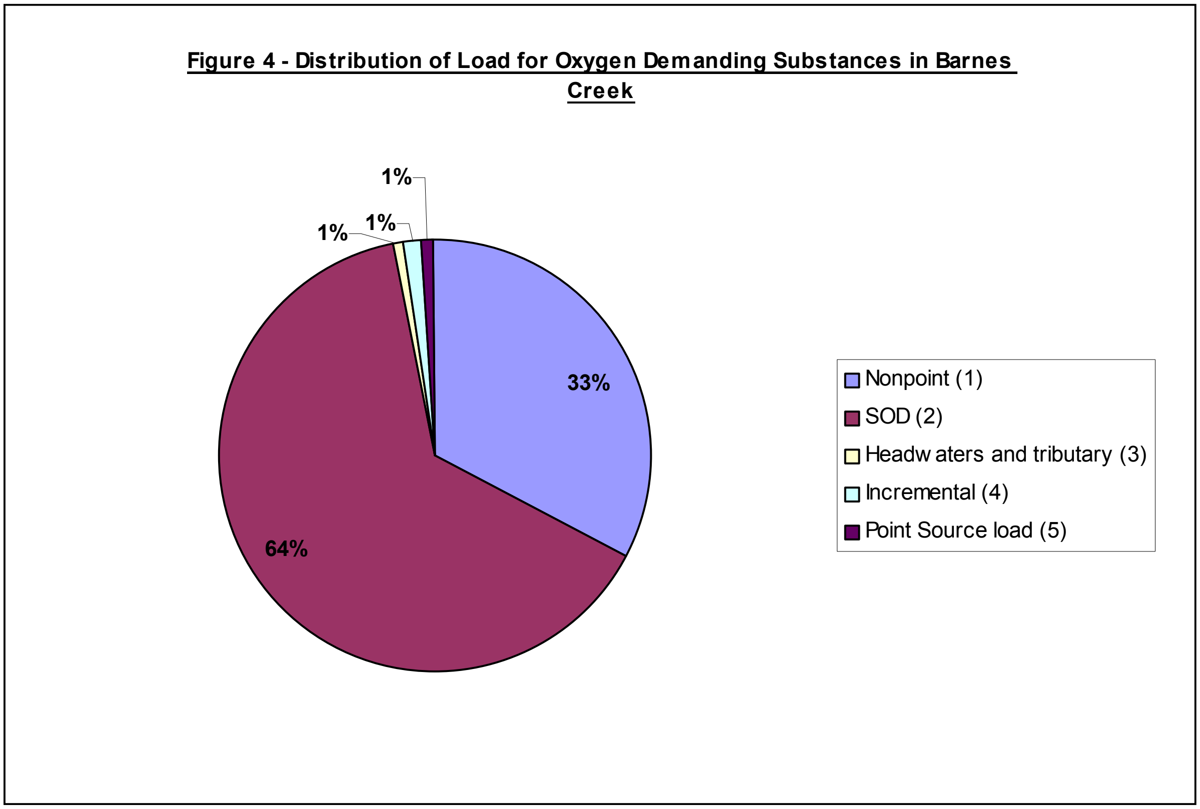


Figure 4. TMDL Load Distribution of Oxygen Demanding Substances for Barnes Creek Watershed. (1) Nonpoint load is the material suspended in the water column. (2) Sediment oxygen demand (SOD) is the benthic load that resides on the stream bottom. (3) Headwaters and tributaries are the loading from tributaries and headwater. (4) Incremental load includes ground water, NPS from rain events, and tributaries. (5) Point source loads are the amount of pollutants discharge in from industrial and municipal point sources in the waterway.

2.1 REQUIRED REDUCTIONS

The TMDL requires a 70% reduction in manmade nonpoint source loads to meet water quality standards. This is a conservative estimate, and should be viewed as such. It is explained in the TMDL that this high reduction is mostly needed to meet the current 5.0 mg/l year round DO standard for 030602.

No reduction in the permit limits for the Waste Water Treatment Plant (WWTP) in the city of DeRidder were required, which is the one point source discharger considered in the model.

2.2 LOAD CONTRIBUTION BY SOURCE

The results indicate that benthic sediments exert a high proportion of the total load, though suspended sediments are also significant. The implication of this includes the probability that historical loading patterns, as well as the current loading modeled by the TMDL are important in understanding the total pollutant load. Detailed discussion of the loading patterns for each stream reach has been included in Section 3.

3.0 STREAM REACHES

3.1 DESCRIPTION OF STREAM REACHES

Image 1. Upper Barnes Creek

There are 22 stream reaches defined by the model (figure 5). Stream reaches 1-3 cover the upper subsegment, 030601, from the headwaters just south of DeRidder to little Barnes Creek. Stream flow is intermittent, which means for part of the year the channel is dry. Land use is dominated by pastureland/grazing in this area of the watershed, with some dairy operations and forestry also present. There is minimal riparian buffer in this section of the watershed (image 1).

It is of cultural significance to note that much of the land in this region is farmed by Mennonites, a religious group related to the Amish. Cultural differences should be taken into account when working with the farmers to implement BMPs.

Image 2. Barnes Creek north of Highway 190

Reaches 5-14, from Little Barnes Creek to highway 190, show a very different pattern of land use. Commercial pine covers much of this area of the watershed, and the main channel shows an intact riparian buffer system of bottomland hardwoods (image 2). The area also contains longleaf pines and pine bogs, containing rare species of herbaceous plants. Highway 171 crosses Barnes Creek just before reach 4 and cuts through the watershed to run north and south (image 3). Therefore, road construction/maintenance activities on highway 171 should be carried out in a way that is sensitive to the potential effects on the Barnes Creek system.

Figure 5 Vector Diagram of Barnes Creek Watershed.

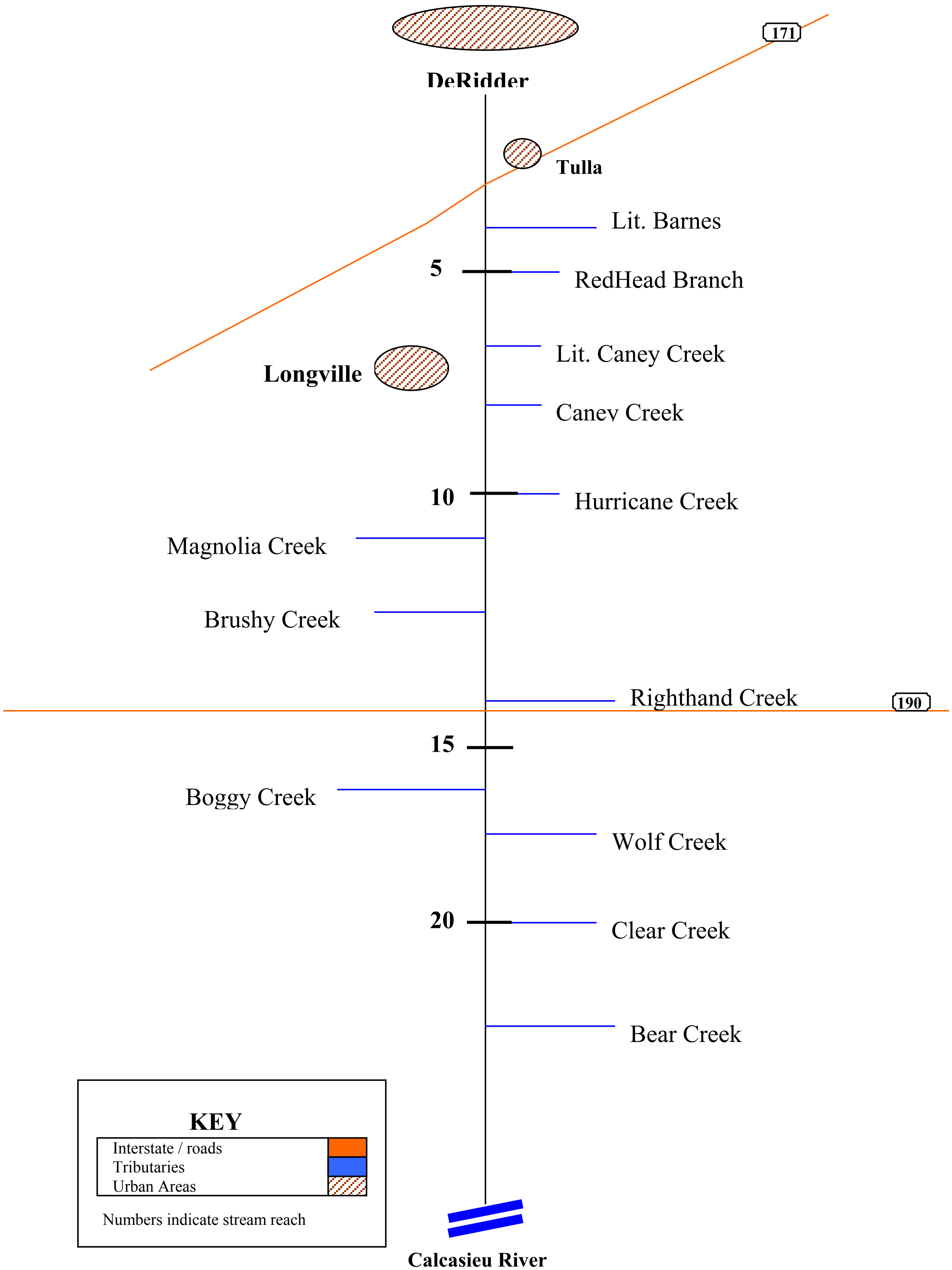


Figure 6 Vector Diagram of Barnes Creek Watershed.

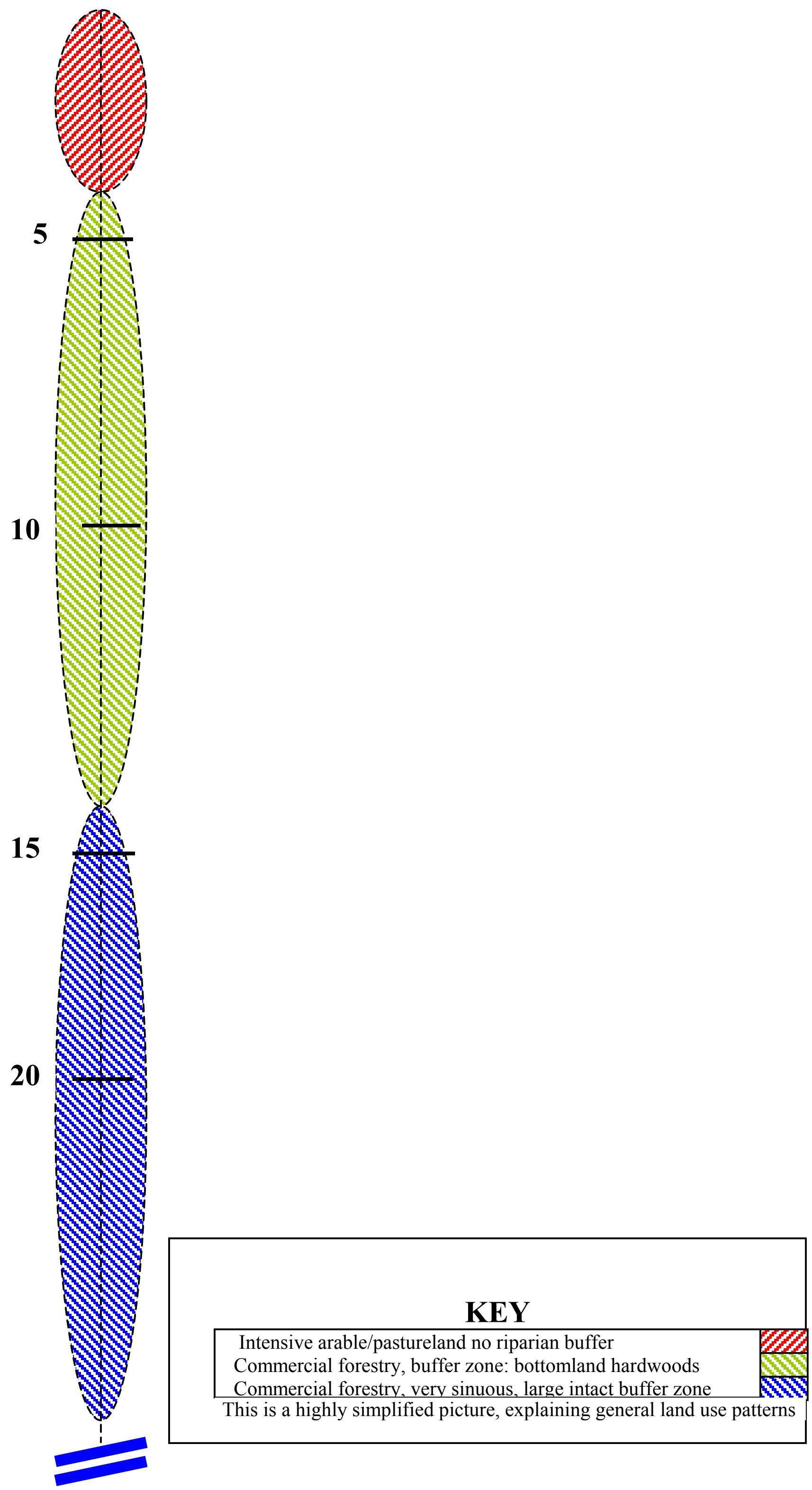


Image 3. Construction on Hwy 171

The lower part of Barnes Creek is dominated by forestry, a mixture of pine, long leaved pine, and bottomland hardwoods. The river widens over reaches 15 – 21 and becomes very sinuous, showing very little signs of hydromodification. Reach 22 is particularly wide, and this is reflected in the loading patterns.

Image 4. Lower Barnes Creek

3.2 MODEL RESULTS

Figure 7 shows the calculated total loading by stream reach generated by the model. The data doesn't show any significant trends, except for a relatively high loading rate at reach 22 (260 kg/day/river km). Loading rates vary over stream reaches 1-21 from relatively low values of loads of around 6.9 kg/day/river km to approximately 59.5 kg/day/river km. It is important to realize this data reflects where the load is exerted, and not necessarily where it originated. Load is associated with nutrient laden sediments, which may be deposited downstream from where they entered the system. In this way the data actually reflects not loading to the system, but exerted load to each stream reach. When an oxygen demanding load is exerted from deposited sediments it is defined as Benthic, or Sediment Oxygen Demand (SOD). SOD may represent historical loading. The data in figure 7 is limited because it does not take into account the increasing width of the stream channel. The exerted load in a wide stream channel, expressed as kg/day, is naturally higher than the exerted load in a narrow stream channel, expressed in kg/day. This may reflect a higher concentration of exerted load, but is also influenced by a greater flow in gallons/day, associated with the wider channel. To avoid this bias the data was converted to grams oxygen demand per m^2 surface area of stream reach per day. The exerted total load per surface area of stream reach per day is plotted in figure 8, and shows a very different pattern. The exerted loading by stream reach is dominated by a peak around reaches 15-16 (max. 11.84 g O_2/m^2/day), with smaller peaks at reach 1 (7.02 g O_2/m^2/day) and at reach 22.

Figure 7 Total Load by reach number

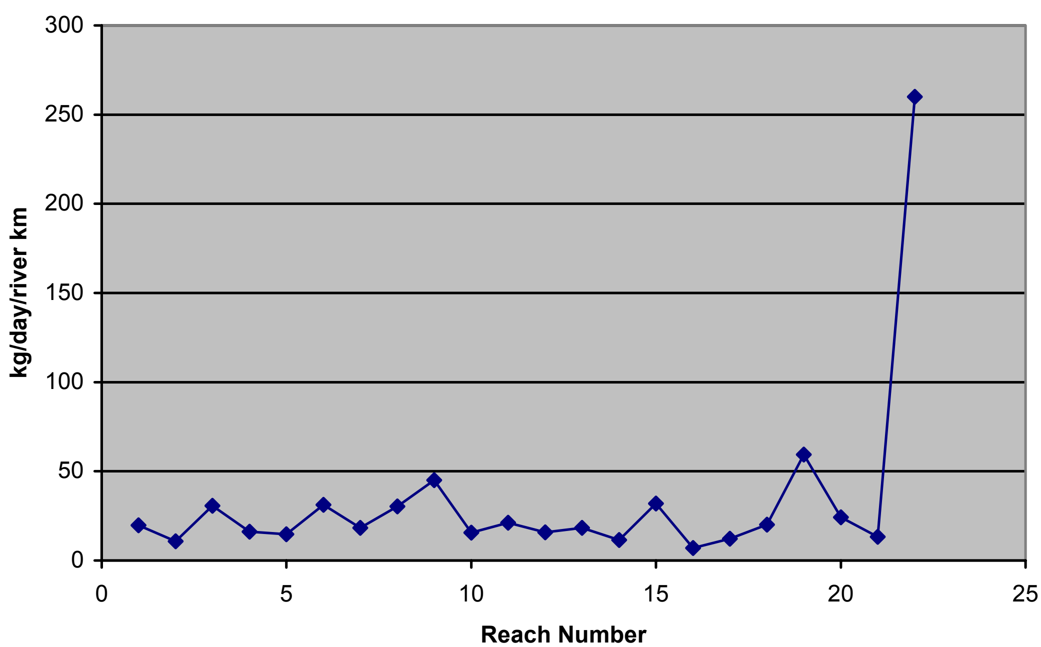


Figure 8 Total Loading 'Width Compensated'

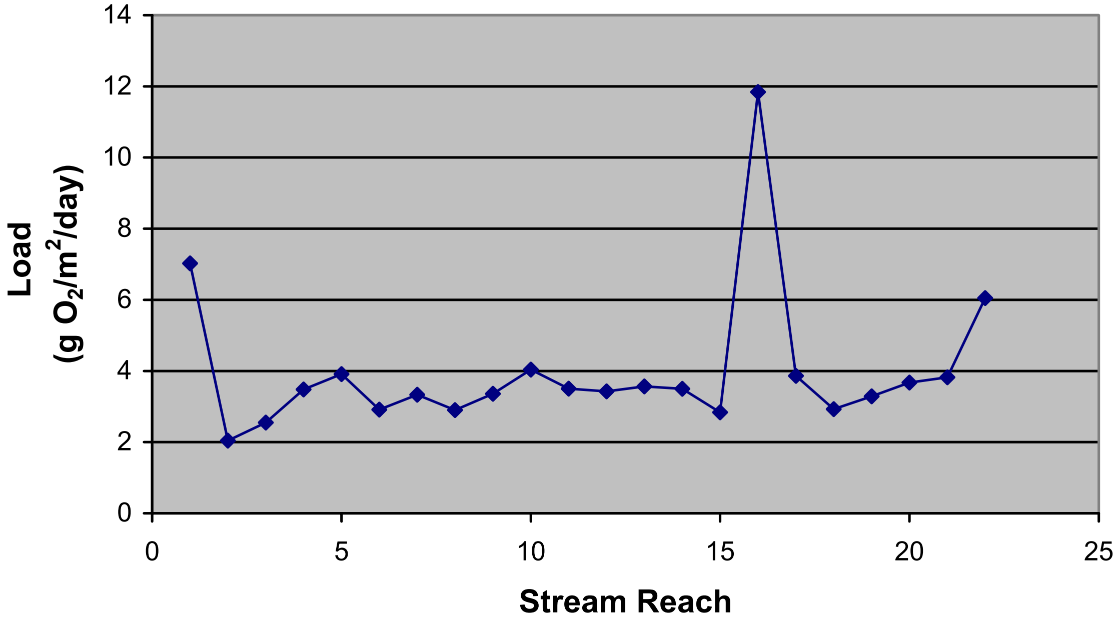


Figure 9 Nonpoint Loading 'Width Compensated'

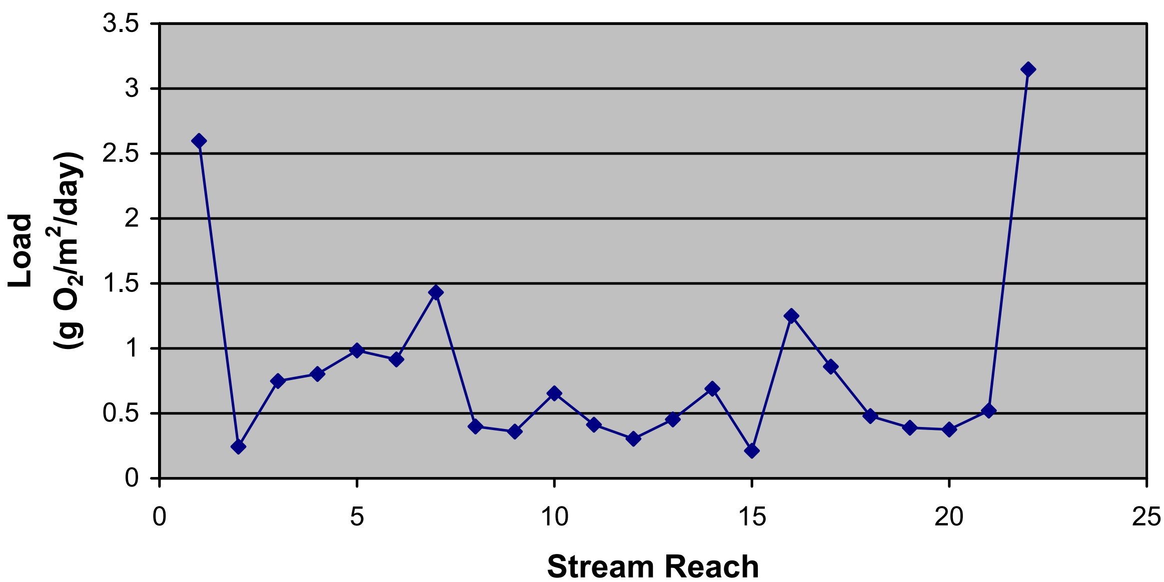


Figure 9 shows just the load contributed by suspended sediments (nonpoint loading) per m^2 surface area per day. There are notable peaks in reaches 1-2 (2.6 g O_2/m^2/day), and 22 (3.1 g O_2/m^2/day). There are also smaller peaks at reach 7 (1.43 g O_2/m^2/day) and at reach 16 (1.25 g O_2/m^2/day).

To summarize the analysis of the loading data; SOD seems to make up a high proportion of the total load. The loading patterns are difficult to interpret, but generally suggest that reaches 1-2 and 22 may be areas where relatively high nonpoint loads are exerted. This does not necessarily reflect the patterns of loading to the watershed, but only where the load is being exerted. It is highly probable that the loading exerted in reach 22, since this is at the bottom of the watershed, reflects the deposition of loading that is occurring upstream. Looking at the ambient water quality data, this is where the water velocity slows and the stream channel becomes highly sinuous. This part of the main channel has a large intact riparian system of bottomland hardwoods.

4.0 WATER QUALITY

Barnes Creek was part of the 1999 ambient water quality monitoring program. During 1999, the water quality was monitored by LDEQ on a monthly basis at the crossing of the Highway 171 Bridge on Barnes Creek. The ambient water quality data for 1999 from the sampling stations in subsegment 030601 and 030602 are displayed in tables 2 and 3 respectively.

The water quality data collected from Barnes Creek Watershed was assessed in the 2000 305(b) report. During the months of October and December, the water quality standard for dissolved oxygen (5 mg/L) was not met (table 2). The year round water quality standard for dissolved oxygen in subsegment 030602 (5.0 mg/l) was not met during the months of April, May, July, August, September, October, and November (table 3). Based upon this data, both subsegment 030601 and 030602 were found to be "not supporting" their designated uses of Fish and Wildlife Propagation. Both subsegments were found to be “fully supporting” their other listed designated uses.

Under the 5year cyclic basin monitoring program, Barnes Creek will be sampled monthly from January to December 2004, and again in 2009 and 2014.

Table 2. Ambient Water Quality Data 030601

Date	Temp. (0C)	D.O. (mg/l)	NO2+NO3 (mg/l)	T.K.N. (mg/l)	Total P (mg/l)	Turb. (NTU)	T.S.S. (mg/l)	T.D.S. (mg/l)
1/12/1999	9.52	8.62	0.17	0.81	0.17	31	10.5	202
2/9/1999	8.35	9.18	0.02	1.34	0.67	36	54	92
3/9/1999	16.58	5.37	0.25	1.11	0.47	33	26	312
4/13/1999	19.62	4.42	2.23	0.51	0.35	19	10	150
5/11/1999	20.8	5.88	0.97	1.17	0.8	31	24.5	176
6/8/1999	24.64	3.25	0.46	0.85	1.86	12	11	221.9
7/13/1999	24.62	5.7	0.45	0.67	0.95	11	6	141.1
8/10/1999	27.44	3.2	0.29	0.68	1.59	6.3	8.5	211.9
9/15/1999	22.93	3.91	0.16	0.55	2.15	5.7	6.7	192
10/12/1999	22.31	4.13	1.1	0.83	1.75	6.3	4	230
11/9/1999	13.97	6.65	0.49	0.59	1.62	7.4	4.8	167.9
12/14/1999	12.68	4.58	0.47	0.44	1.18	50	8.7	209

Table 3. Ambient Water Quality Data 030602

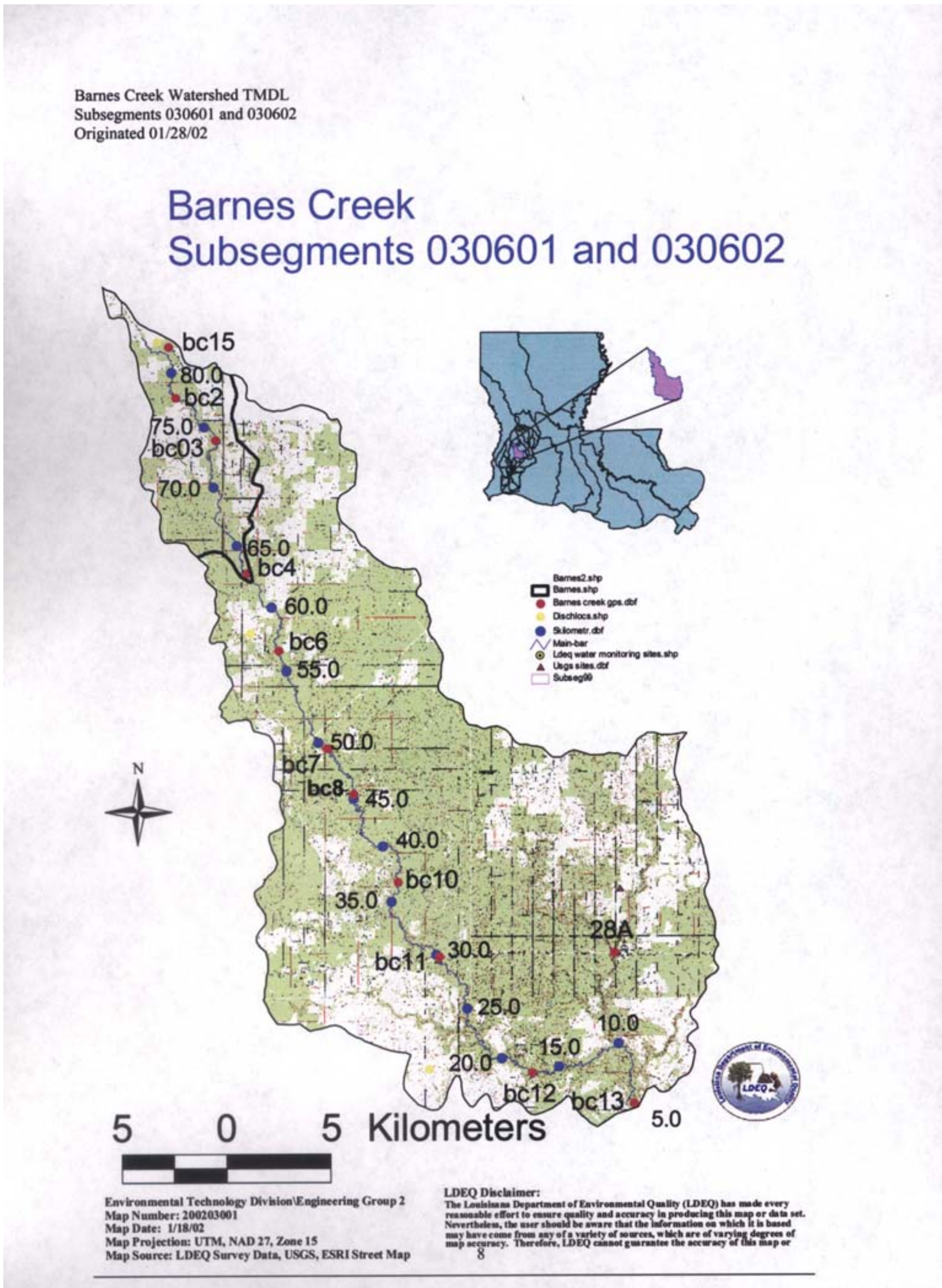
Date	Temp. (0C)	D.O. (mg/l)	NO2+NO3 (mg/l)	T.K.N. (mg/l)	Total P (mg/l)	Turb. (NTU)	T.S.S. (mg/l)	T.D.S. (mg/l)
1/20/1999	14.22	5.36	0.04	0.39	0.13	24	8.5	73.9
2/18/1999	14.37	5.3	0.12	0.73	0.16	55	68	98
3/17/1999	12.83	6.47	0.09	0.64	0.08	36	21.1	262
4/21/1999	18.73	1.92	0.12	0.43	0.2	40	12	160
5/19/1999	23.77	2.66	0.15	0.7	0.13	27	11	106
6/16/1999	24.8	5.02	0.06	0.75	0.08	43	28	98
7/21/1999	25.92	2.32	0.12	0.75	0.18	28	10	117
8/18/1999	27.39	2.71	0.04	0.34	0.12	17	22	123
9/22/1999	22.28	3.85	0.03	0.21	0.25	22	23	125
10/20/1999	19.1	3.06	0.04	0.37	0.15	23	23	135
11/17/1999	14.7	4.56	0.03	1.53	0.12	9.8	10.5	126
12/22/1999	9.08	9.05	0.21	0.76	0.16	55	21.1	90.7

In addition to the ambient monitoring, water quality data was collected from 13 sampling stations along the Barnes Creek watershed (figure 10) during the months of August and September 1999 in order to develop the TMDL. This data (table 4) was collected to determine the total load that existed within the waterbody during the critical condition and was the primary source of input for the TMDL model.

Table 4. TMDL input data for one sampling date

Sampling Site	DO (mg/l)	Temp. (0C)	BOD (mg/l)	NO2+NO3 (mg/l)
bc2	2.88	26.83	2.65	0.56
bc3	4.46	26.02	2.49	0.37
bc4	4.23	26.34	3.53	0.09
bc6	3.01	26.42	3.5	0.1
bc7A	0.57	25.55	5.54	0.07
bc7B	4.03	25.7	-	-
bc8	2.68	25.74	4.38	0.09
bc10	2.44	25.61	3.41	0.08
bc11	2.58	25.15	4.08	0.08
bc12	3.2	27.22	4.32	0.1
bc13	1.38	26.12	5.12	0.06
bc15	4.67	28.17	-	-
bc28	4.38	25.56	-	-

Figure 10 – Sampling Sites on Barnes Creek.



Taken from the Barnes Creek TMDL for dissolved oxygen
(LDEQ, 1999)

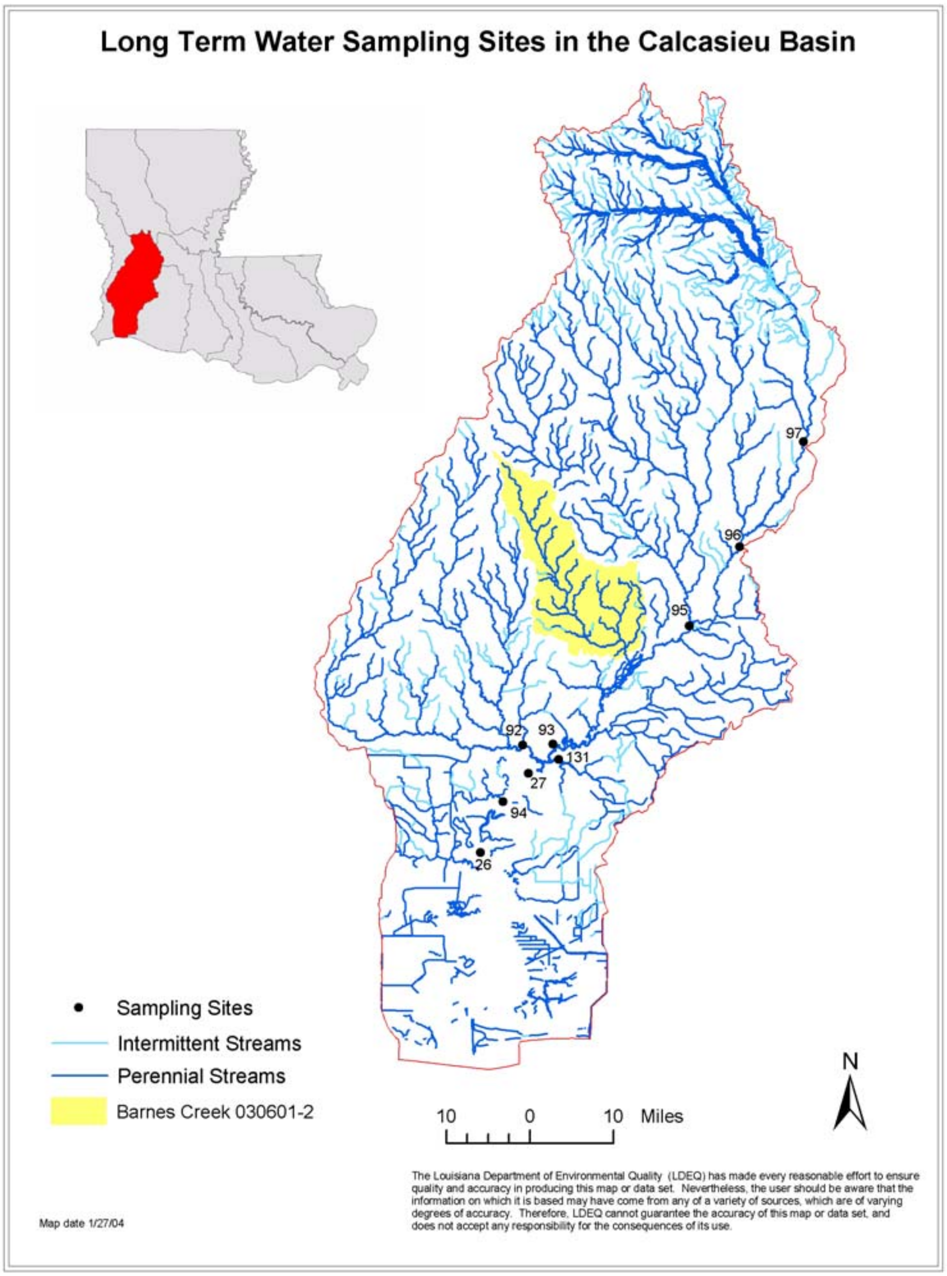
Only one year of ambient data is available for the Barnes Creek Watershed. Since it is difficult to establish trends based on such a small data set and many of the changes in water quality data throughout the year are unexplainable by the information available, historical data from additional sites in the Calcasieu Basin has been included.

There are nine historic water quality network sites in the Calcasieu Basin (table 5, figure 11), some of which have data from as far back as 1958. For comparison, sampling sites were split into three groups: Upper Calcasieu, Lower Calcasieu, and Tributaries. The Upper Calcasieu consists of sites 93, 95, 96, and 97, which are on the Calcasieu River upstream of the saltwater intrusion barrier. The Lower Calcasieu consists of sites 26 and 27, which are on the Calcasieu River downstream of the saltwater intrusion barrier. Sites 92, 94, and 131 are on the tributaries to the Calcasieu River and make up the Tributary group for analysis. Land use in Barnes Creek Watershed appears to be most similar to that in the Upper Calcasieu.

Table 5. Sampling Locations in Calcasieu Basin

SITE NUMBER	SUBSEGMENT	DESCRIPTION	YEAR SAMPLING BEGAN	LAST YEAR SAMPLED
26	030304	Calcasieu River near Burton Landing, Louisiana	1971	2001
27	030301	Calcasieu River near Lake Charles, Louisiana	1971	1998
92	030801	Calcasieu River (West Fork) near Lake Charles, Louisiana	1971	1999
93	030201	Calcasieu River at Moss Bluff, Louisiana	1958	2001
94	030901	Bayou D'Inde near Lake Charles, Louisiana	1978	1998
95	030103	Calcasieu River near Kinder, Louisiana	1958	1999
96	030103	Calcasieu River northwest of Oberlin, Louisiana	1967	1998
97	030103	Calcasieu River near Oakdale, Louisiana	1958	1998
131	030702	English Bayou near Lake Charles, Louisiana	1984	1998

Figure 11. Long Term Water Sampling Sites in the Calcasieu Basin.



The data from all sites and all years reveals some characteristic seasonal trends. From March to August, dissolved oxygen values (figure 12) decline and appear to correspond to increasing water temperature. The turbidity data (figure 13) was similar to what one might expect with higher values during the winter and spring months and dropping off in the summer through the fall, possibly corresponding to rainfall events and field activity. Whereas April does not seem to show a spike or elevated level for turbidity, it did seem to have a higher value for TKN (figure 14), nitrate/nitrite (figure 15) and total phosphorus (figure 16) that may be related to rice discharge or fertilization of crops, forests, and lawns. Water clarity, as measured by the secchi disk (figure 17), seemed to also exhibit a seasonal pattern of lower clarity during the winter and spring months and higher clarity during the summer and fall months. Total organic carbon (figure 18) appears to have a seasonal pattern similar to the TSS pattern (figure 19). TDS (figure 20) trends probably result from saltwater intrusion or increased salinities during the fall months.

Overall, water quality seems a little better in the upper Calcasieu than in the lower Calcasieu and the tributaries. The monthly median values for the lower Calcasieu and the tributaries drop below the 5 ppm dissolved oxygen standard, but the median vales in the upper Calcasieu do not (figure 21). A saltwater intrusion barrier separating the upper and lower Calcasieu can account for the higher TDS values in the lower Calcasieu than in the tributaries or in the upper Calcasieu (figure 22).

In general, nutrient values are consistently higher in the lower Calcasieu and the tributaries. The lower Calcasieu and tributaries drain areas that are primarily pastureland, forested, or urban with the city of Lake Charles comprising a large portion of this area. The peak in nutrients, such as nitrate/nitrite (figure 23), that occurs in April is possibly a result of the fertilization of lawns, forests, or pasture, which is often done during the spring. The turbidity pattern is also interesting with the lower Calcasieu and the tributaries peaking in April and the upper Calcasieu values exceeding them in June through November (figure 24). Additional historic data can be found in appendix 1.

Figure 12. Dissolved Oxygen Medians for all SamplingYears
Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131

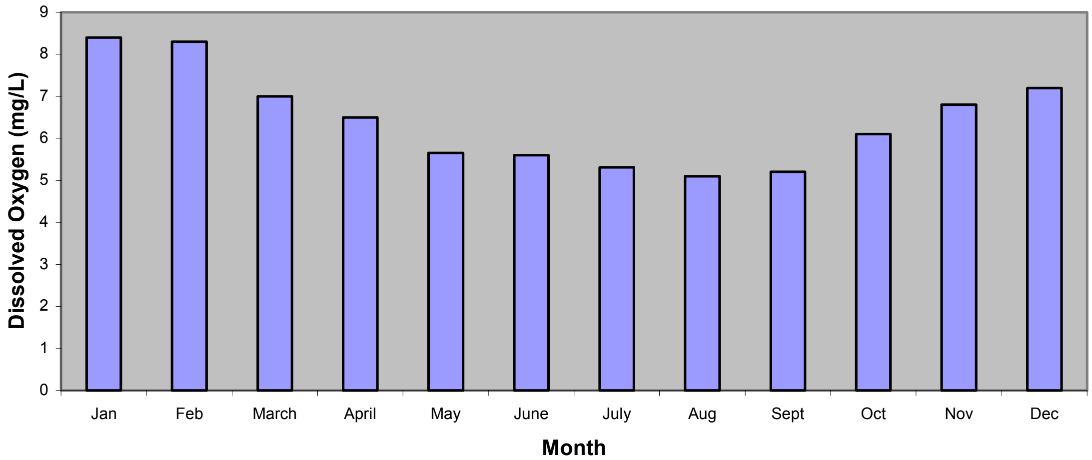


Figure 13. Turbidity Medians for all SamplingYears
Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131

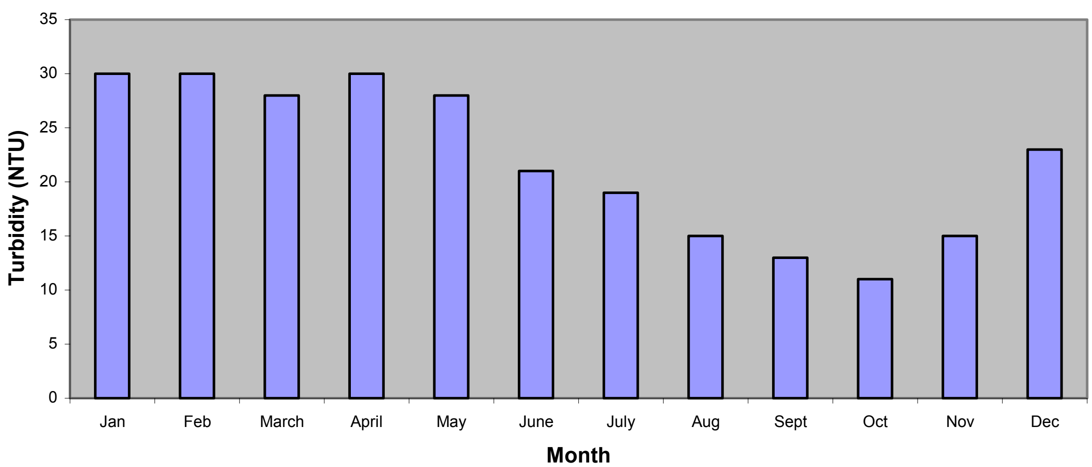


**Figure 14. Total Kjeldahl Nitrogen (T.K.N) Medians for all Sampling Years
Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131**

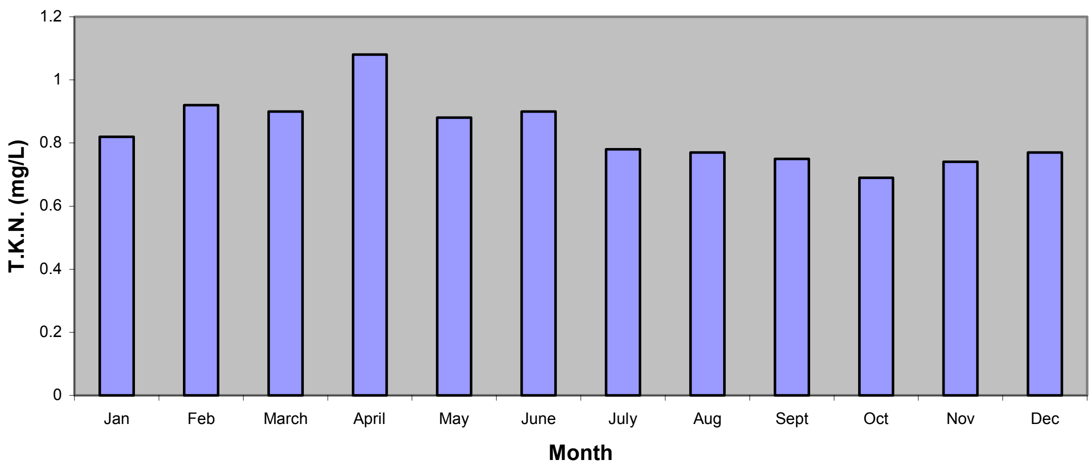


**Figure 15. N02 + NO3 Medians for all Sampling Years
Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131**

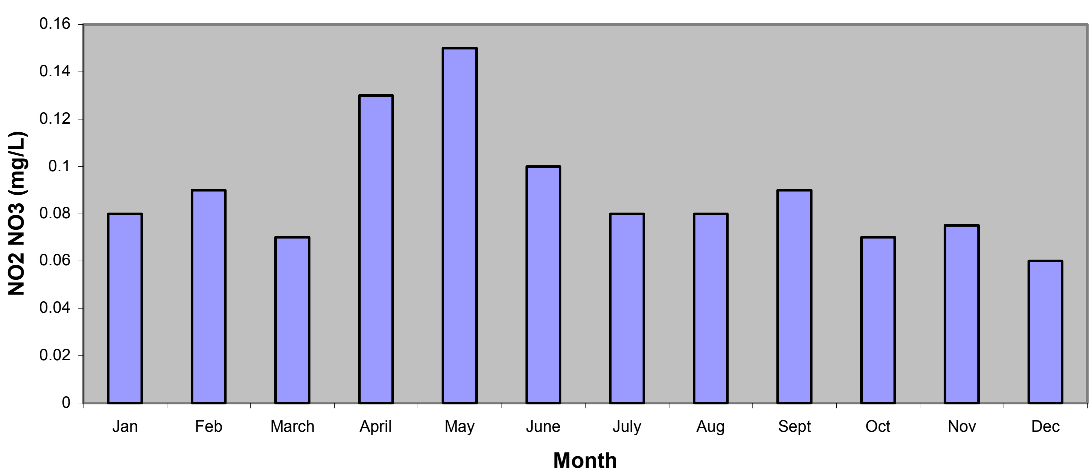


Figure 16. Total Phosphorus Medians for all Sampling Years
Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131

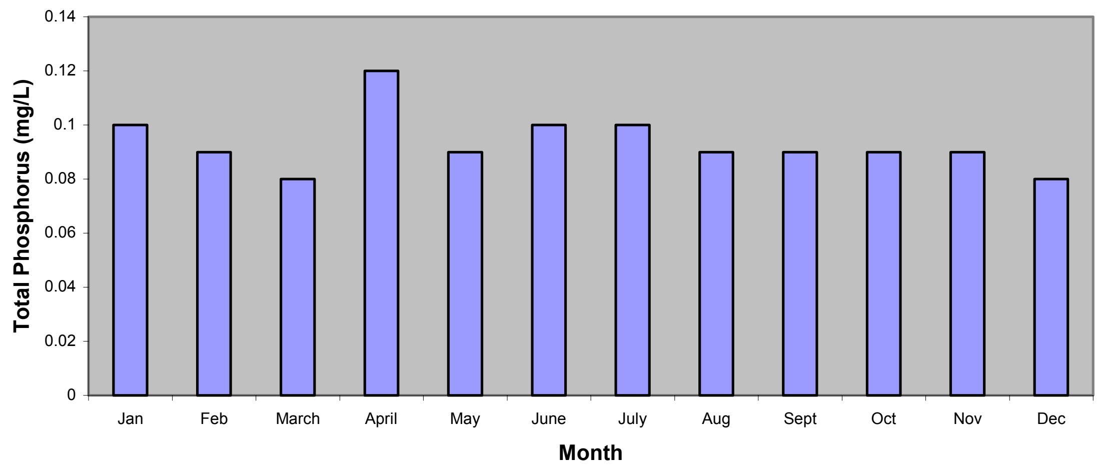


Figure 17. Secchi Disk Medians for all Sampling Years
Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131

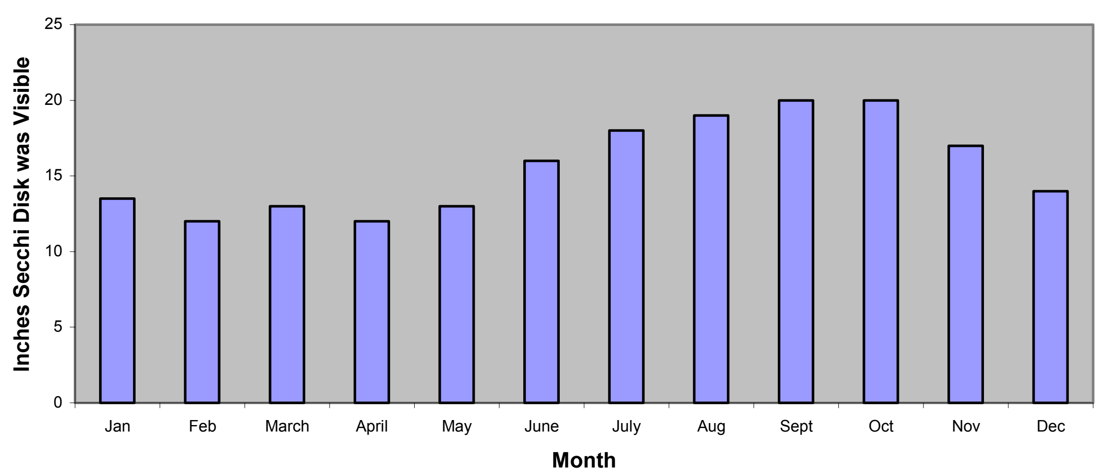


Figure 18 Total Organic Carbon (T.O.C.) Medians for all SamplingYears
Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131

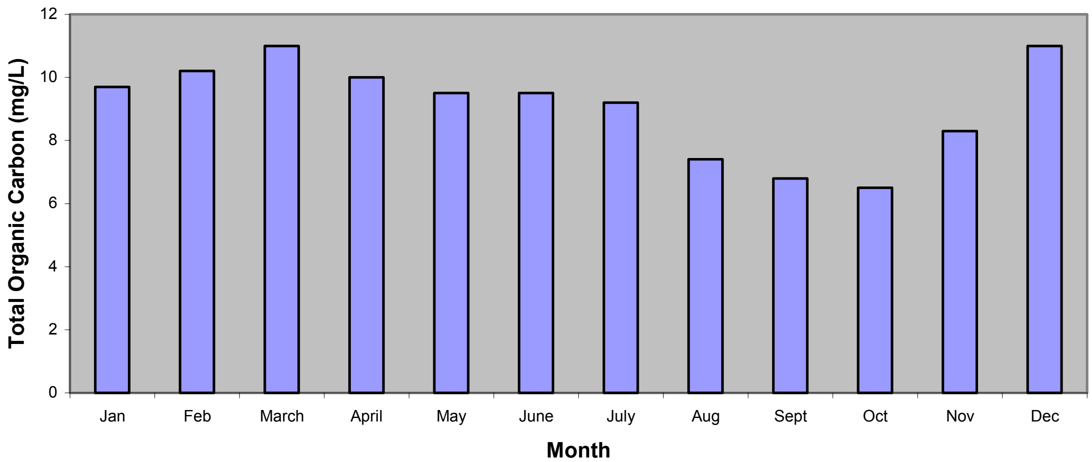


Figure 19. Total Suspended Solids Medians for all Sampling Years
Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131

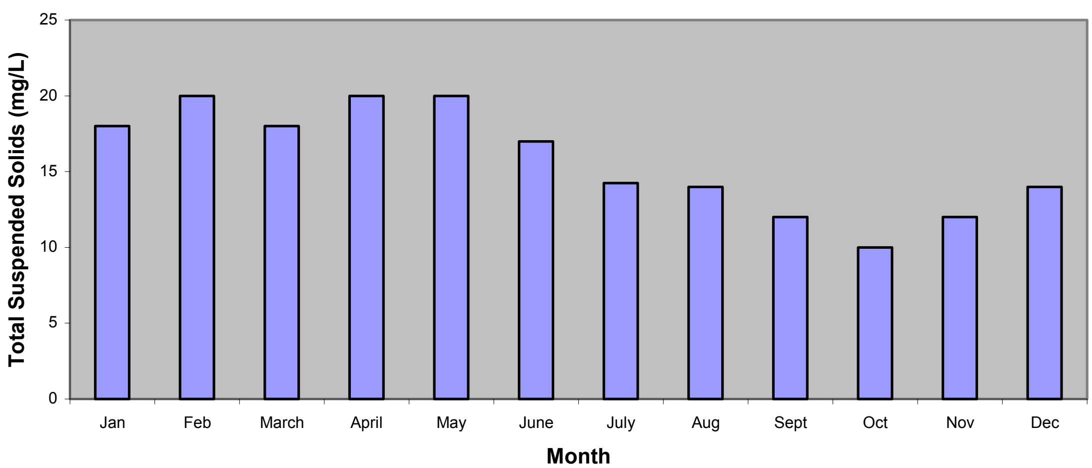


**Figure 20. Total Dissolved Solids (TDS) Medians for all Sampling Years
Stations 26, 27, 92, 93, 94, 95, 96, 97, and 131**

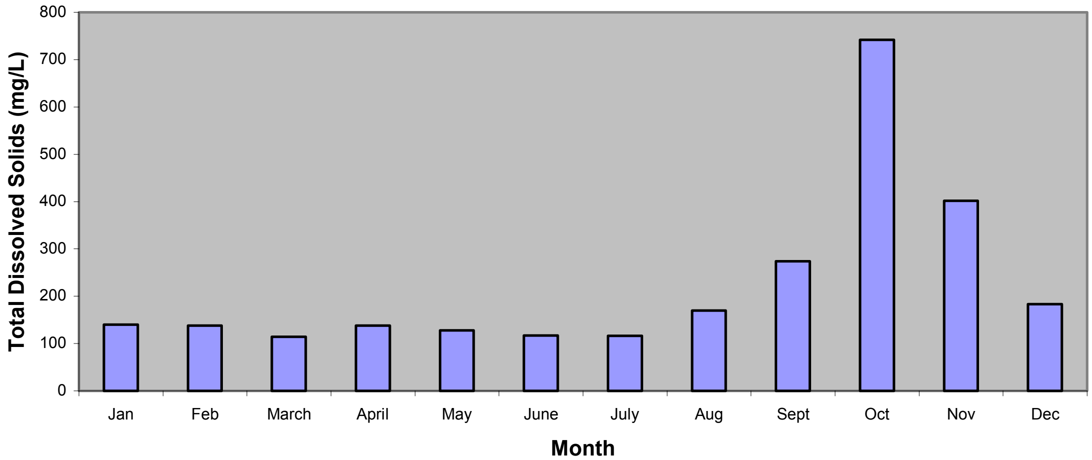


Figure 21. Dissolved Oxygen Median Values from all Sampling Years in the Calcasieu River Basin

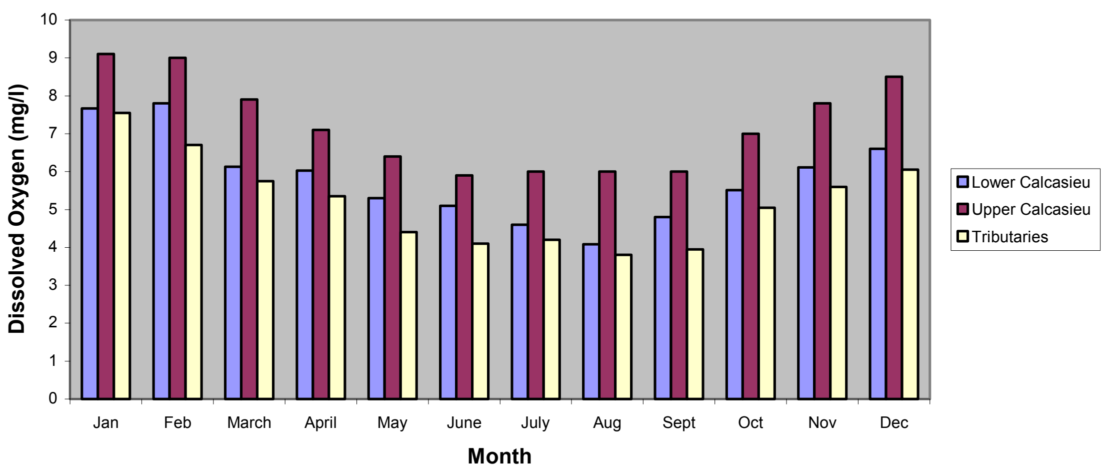


Figure 22. Total Disolved Solids (TDS) Median Values from all Sampling Years in the Calcasieu River Basin

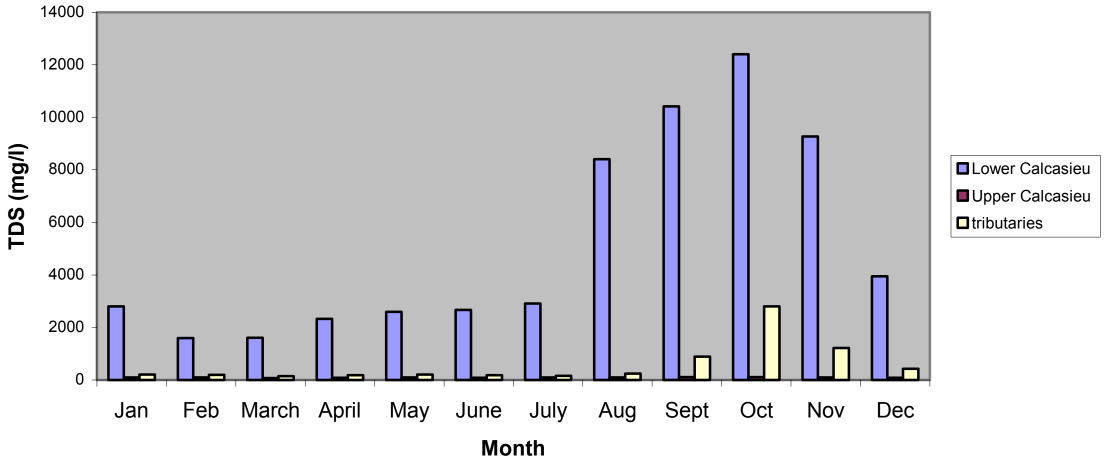


Figure 23. NO2 + NO3 Median from all Sampling Years in the Calcasieu River Basin

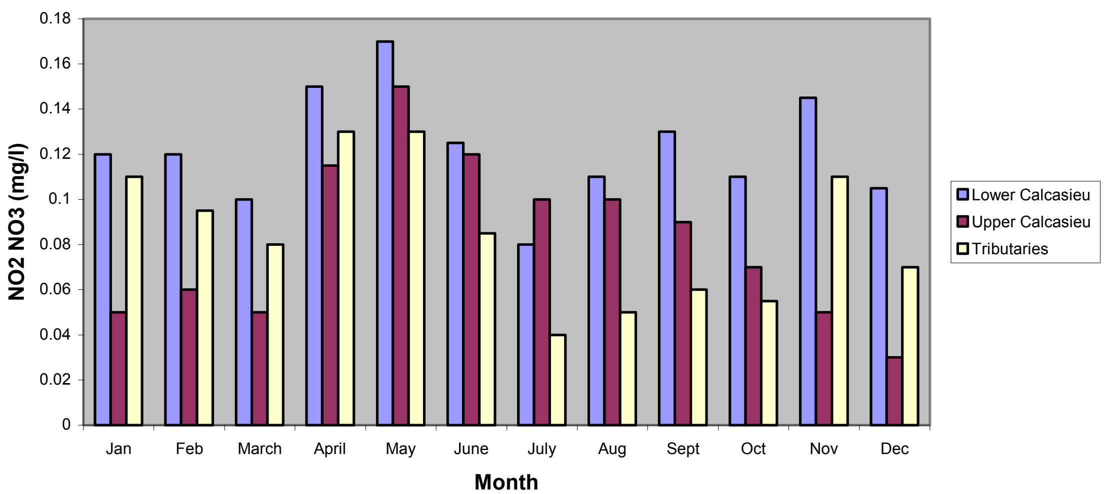
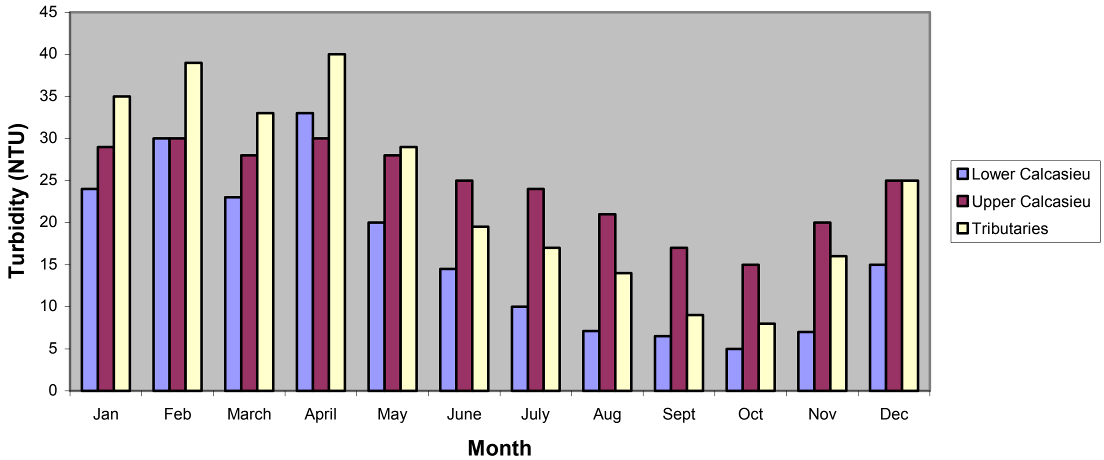


Figure 24. Turbidity Median Values from all Sampling Years in the Calcasieu River Basin



5.0 ANNUALIZED AGRICULTURE NONPOINT SOURCE MODEL

LDEQ is utilizing a model called Annualized Agriculture Non-Point-Source (AnnAGNPS), a Natural Resources Conservation Service (NRCS) sponsored model, to evaluate current sediment loadings in watersheds. The model produces results on sediment, phosphorus, nitrogen, and organics as the constituents travel overland, through the reaches and out the watershed outlet. Cells (land area representations) of a watershed are used to provide landscape spatial variability. Each cell represents the landscape within its respective land area boundary as one homogeneous unit. The physical or chemical constituents are routed from their origin within the land area and are either deposited within the stream channel system or transported out of the watershed. Pollutant loadings can then be identified at their source and tracked as they move through the watershed system.

Type of Model Results	Results	Units	Description
Sediment Erosion	1.249	tns/ac/yr	Overland erosion
Sediment Yield	0.586	tns/ac/yr	Sediment deposited in streams
Sediment Load	0.258	tns/ac/yr	Sediment that moves through stream reaches
Nitrogen Load	1.83	lbs/ac/yr	Nitrogen moving through reaches
Phosphorus Load	23.67	lbs/ac/yr	Phosphorus moving through reaches
Organic Carbon Load	14.82	lbs/ac/yr	Organic carbon moving through reaches
Water Load	9.20	in/ac/yr	Amount of water running of cells into the stream reaches

Table 6 The AnnAGNPS modeling results above for Barnes Creek Watershed are "average annual" runoff of materials over a 30 yr simulation period.

6.0 IDENTIFYING HIGH PRIORITY AREAS IN BARNES CREEK

Watersheds are not homogeneous with regards to their potential for soil erosion. Soil type, the slope of the land, and land use are each important factors in determining the risk to water quality from a given area. Therefore, when determining priority for conservation measures within a watershed both location and activity must be considered. Soils data, sediment loading models, and land use data, are valuable tools that can provide clues as to where potential sources of water pollution may be and which problems can most easily be corrected.

6.1 IMPACT OF SOIL TYPES ON WATER QUALITY

Erosion of soil and transportation to waterbodies can cause a plethora of water quality problems. The addition of soil to surface water can decrease the amount of light reaching submerged vegetation. This decreases photosynthesis and therefore the amount of oxygen being released into the water. Furthermore, when the vegetation dies, bacteria will consume additional oxygen from the water as they degrade the plant material. Chemicals such as pesticides, fertilizers, and metals can attach to soil particles and be transported to waterbodies. These chemicals have the potential to directly harm aquatic species or may result in decreased DO as bacteria degrade the compounds.

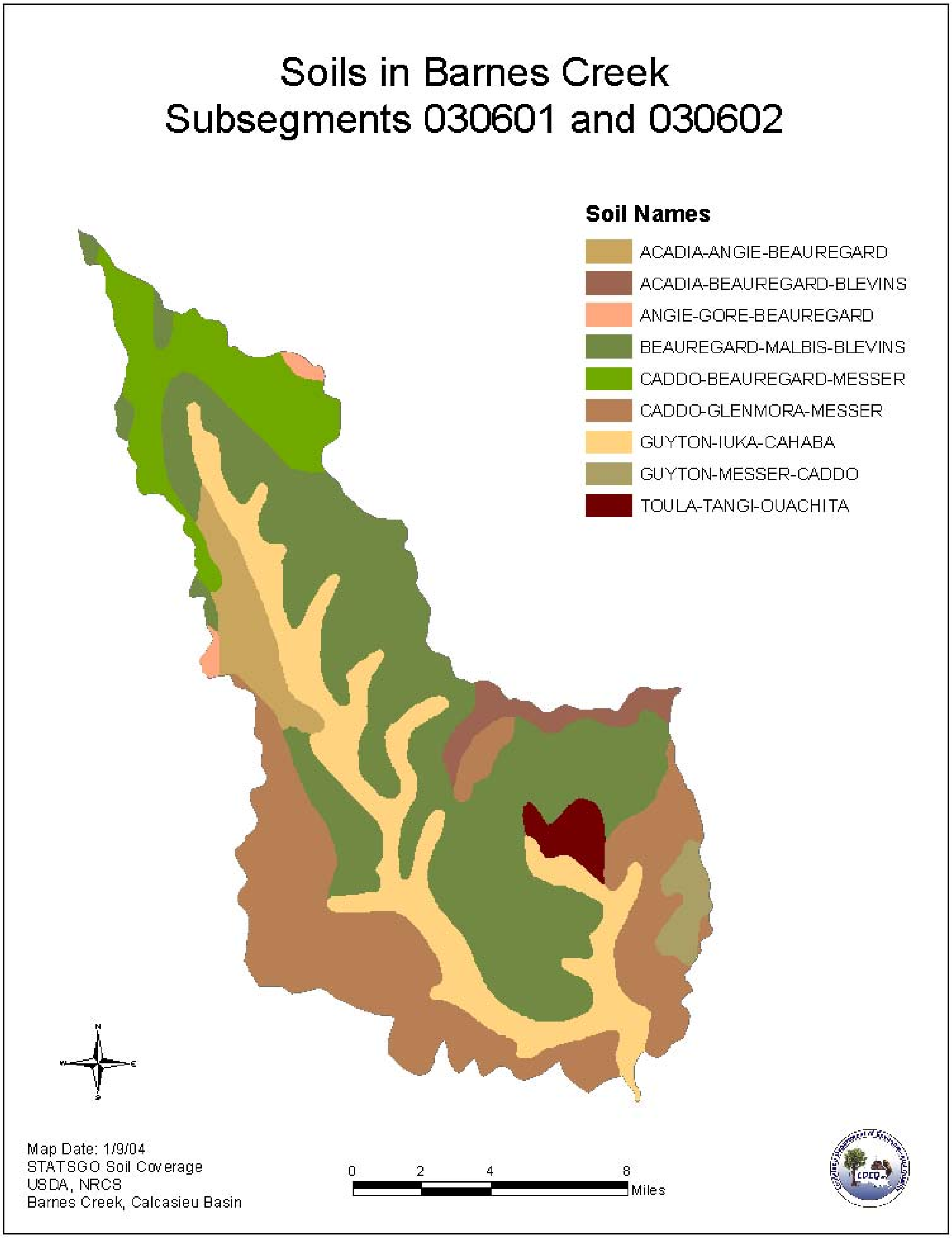
In the Barnes Creek Watershed, most of the soils are relatively impermeable clays (figure 25) that form a natural barrier between the surface water and the groundwater. Groundwater inputs to a watershed system are usually beneficial for water quality because they increase flows and help to ‘flush’ load carrying sediments through. Because of the typically impermeable nature of the soils in the Barnes Creek watershed, groundwater contributions to flow tend to be small, and this has the effect of enhancing dystrophic conditions.

The inherent soil erodability may also be critical in determining loading rates. It is possible that two different stream reaches with the same land use patterns may have different loading rates, because one area has underlying soils, which are more susceptible to erosion. For this reason, this section of the plan examines the inherent erodability of the different soils in the Barnes Creek Watershed. Erodability of soils is a function of the properties of the soil and the slope.

6.2 SEDIMENT RUNOFF

Sediment run off is principally related to land use, slope (LS Factor), soil erodibility (K-Factor), and rainfall intensity. These variables are the most significant factors affecting agricultural NPS pollution. AnnAGNPS estimates three general types of soil erosion: sheet, rill, and gully. In AnnAGNPS, sheet erosion is considered to be removed uniformly from every part of the cell. Rill and gully erosion create small or large ravines by undermining and downward cutting of soils. Gully erosion is larger and more pronounced rill erosion. Gullies eventually produce ditches or ravines exposing subsoils to erosion. AnnAGNPS estimates sheet, rill, and gully erosion for each cell. The results for sediment erosion (figure 26), sediment load (figure 27), and sediment yield (figure 28) indicate where these activities are most likely to occur. AnnAGNPS defines Sediment Erosion as the amount of sediment that travels overland to the edge of the cell, Sediment Yield as the amount of sediment that is deposited into the stream network, and Sediment Load as the amount of sediment that travels through the stream network and out the outlet (figure 29). The results are rendered in standard tons/acre/year. Similarly, the model produces runoff and loading for nitrogen, phosphorus, and organic carbon. The nutrient and organic results are rendered in lbs/acre/yr (table 6). In addition, the model predicts how much water runs off a watershed cell (table 6).

Figure 25. Soils in Barnes Creek Watershed



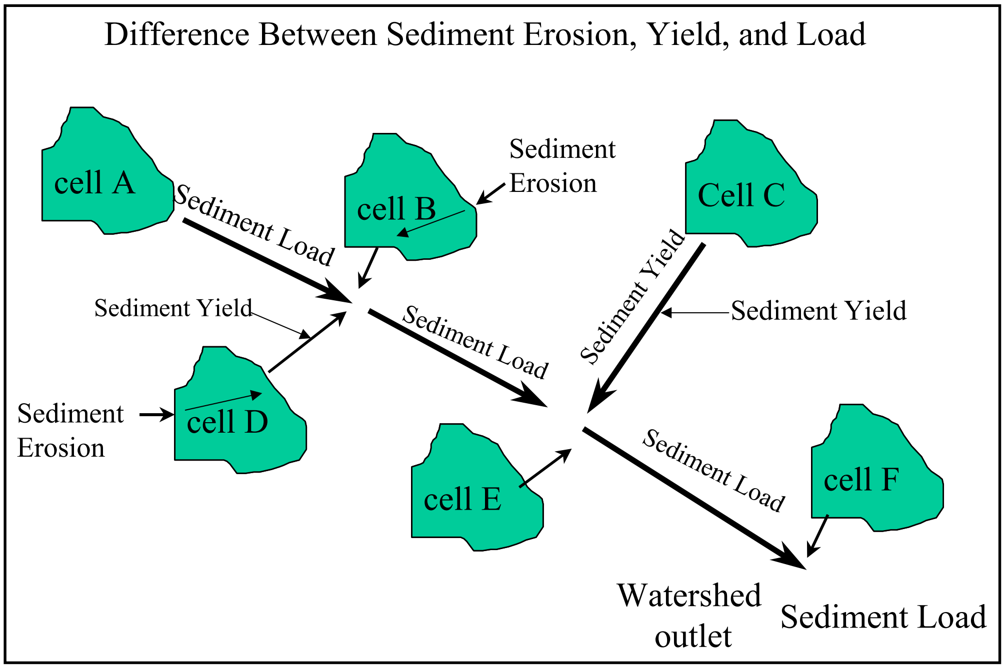


Figure 29 AnnAGNPS describes soil run-off in 3 basic categories: 1) Sediment Erosion is soils moving across the cells; 2) Sediment Yield is the soils of the cell depositing into the stream; 3) Sediment Load is the soil moving through the stream from reach to reach.

Figure 26. Sediment Erosion in Barnes Creek

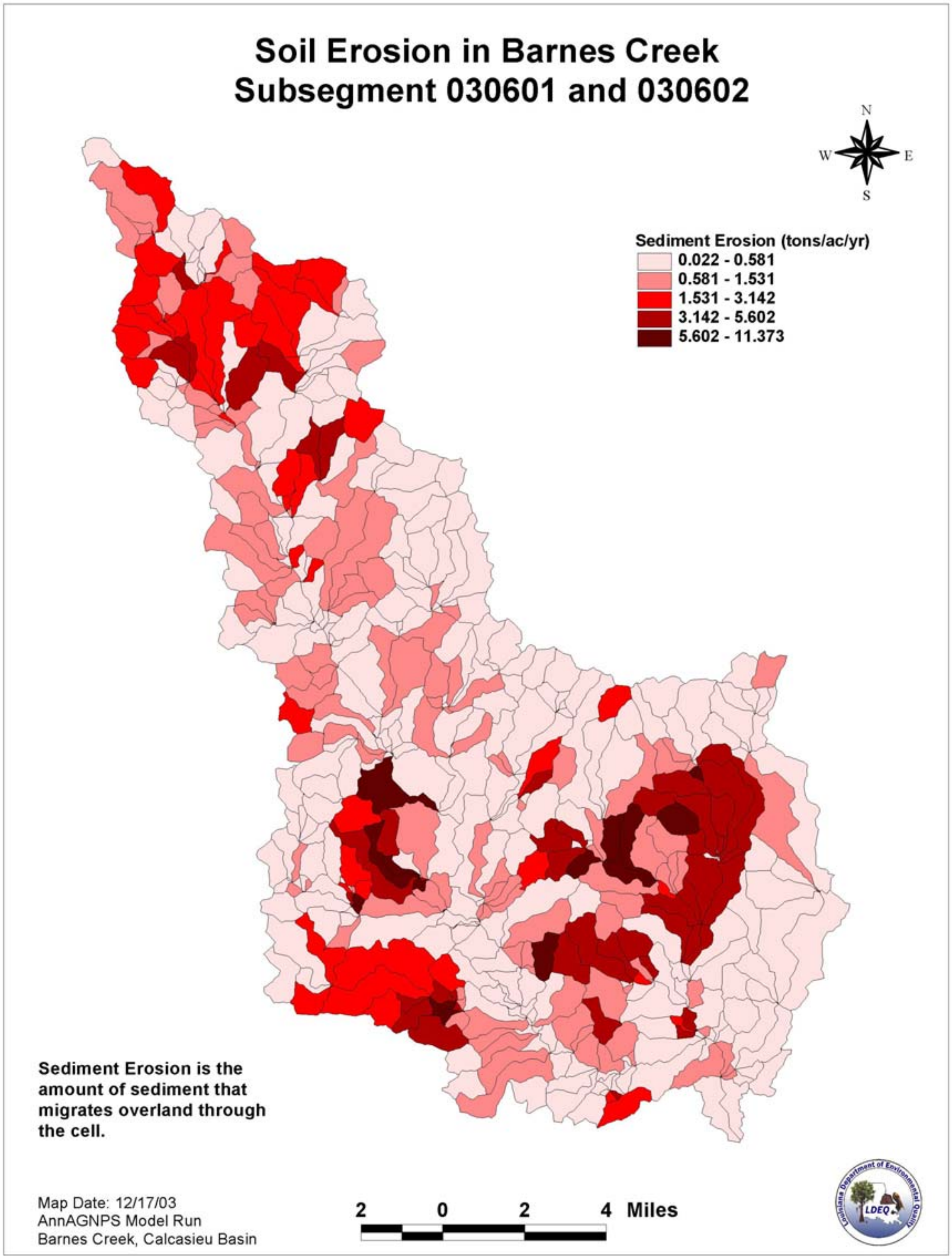


Figure 27. Sediment Loading in Barnes Creek

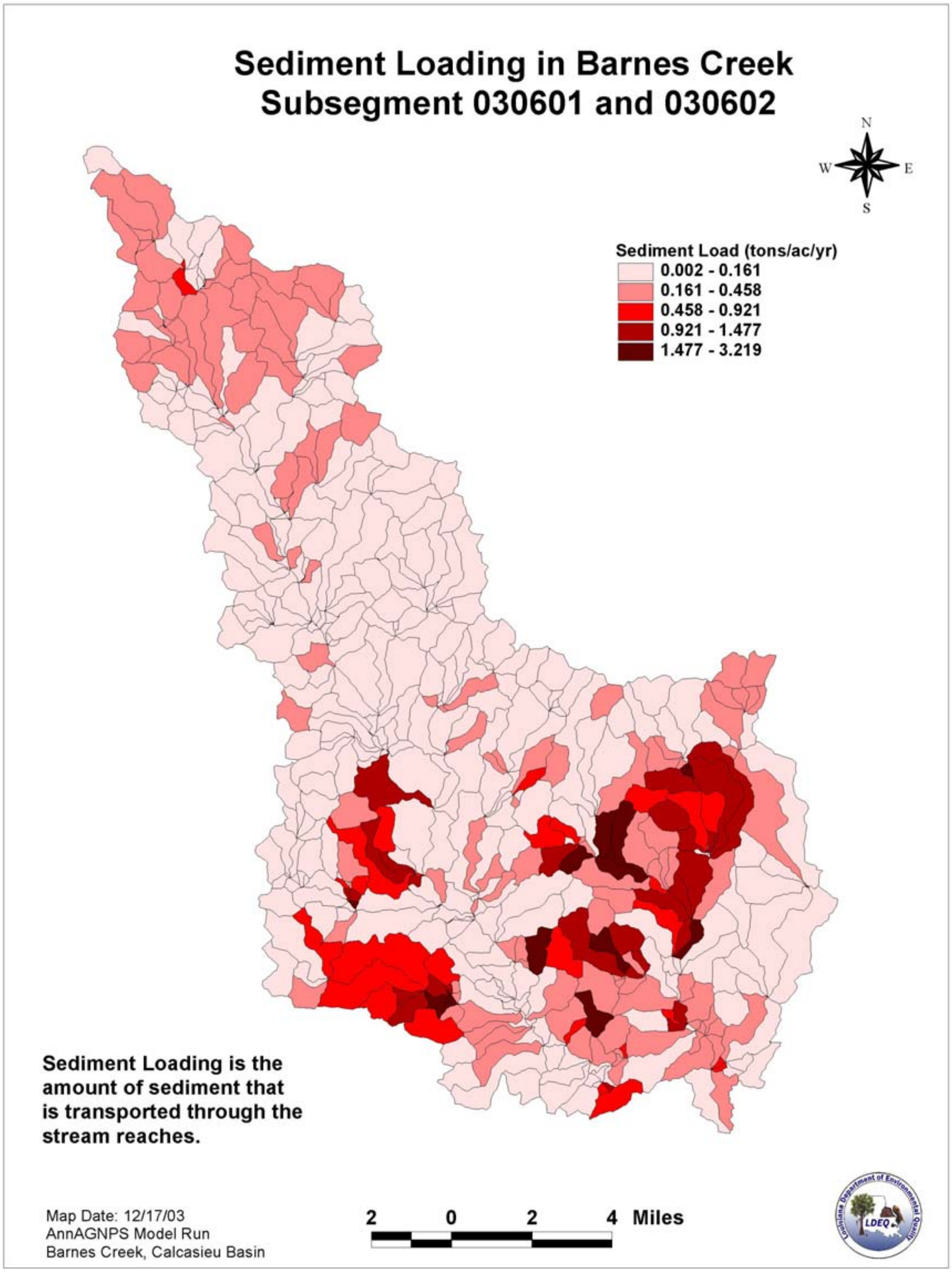
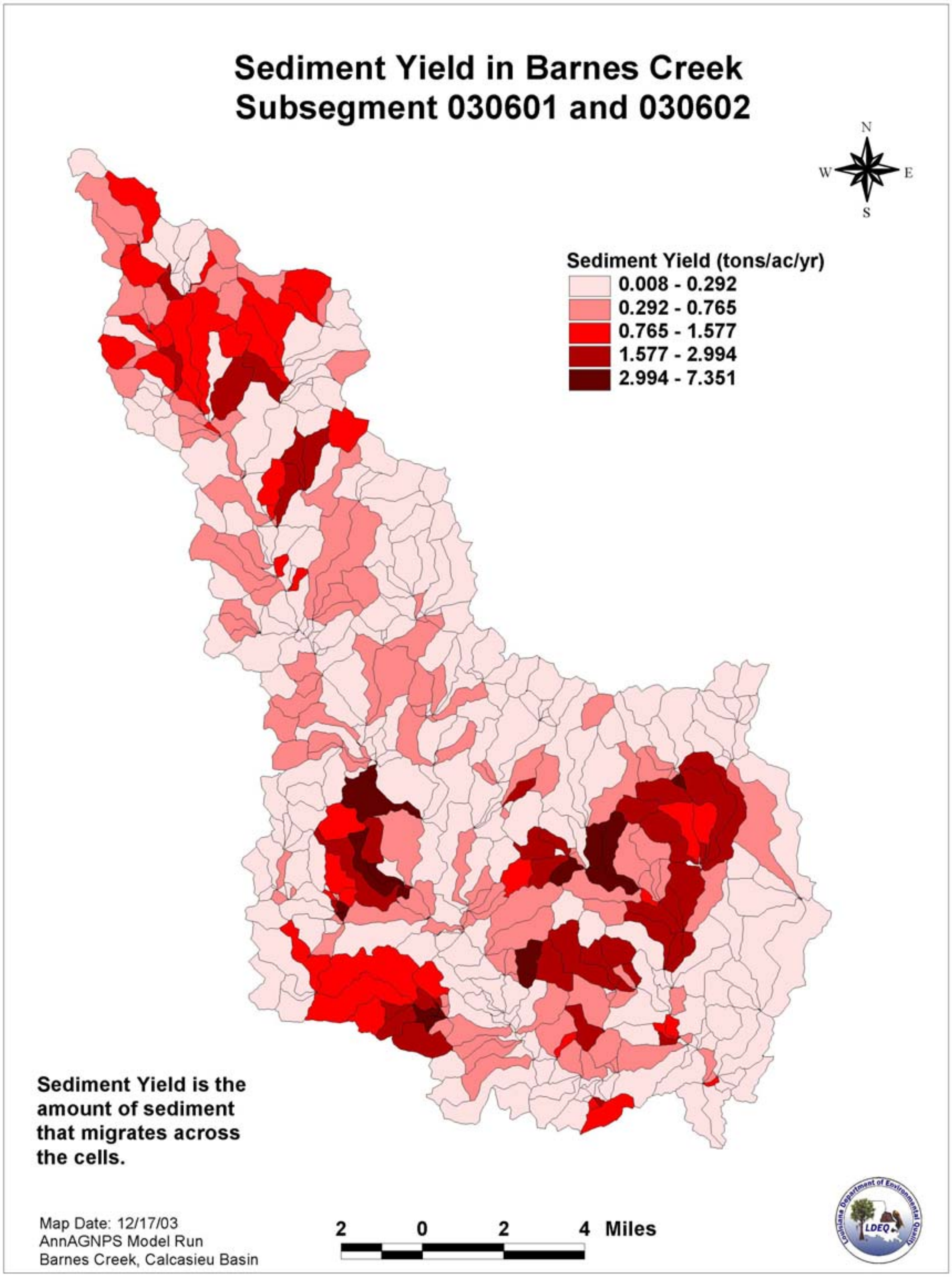


Figure 28. Sediment Yield in Barnes Creek



6.3 WATER RUNOFF

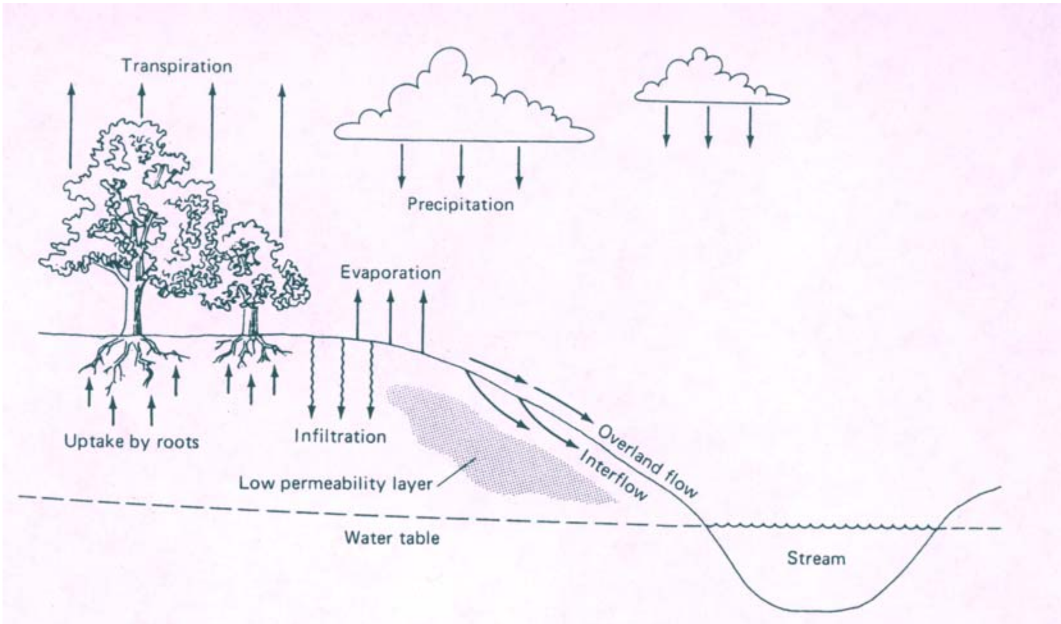
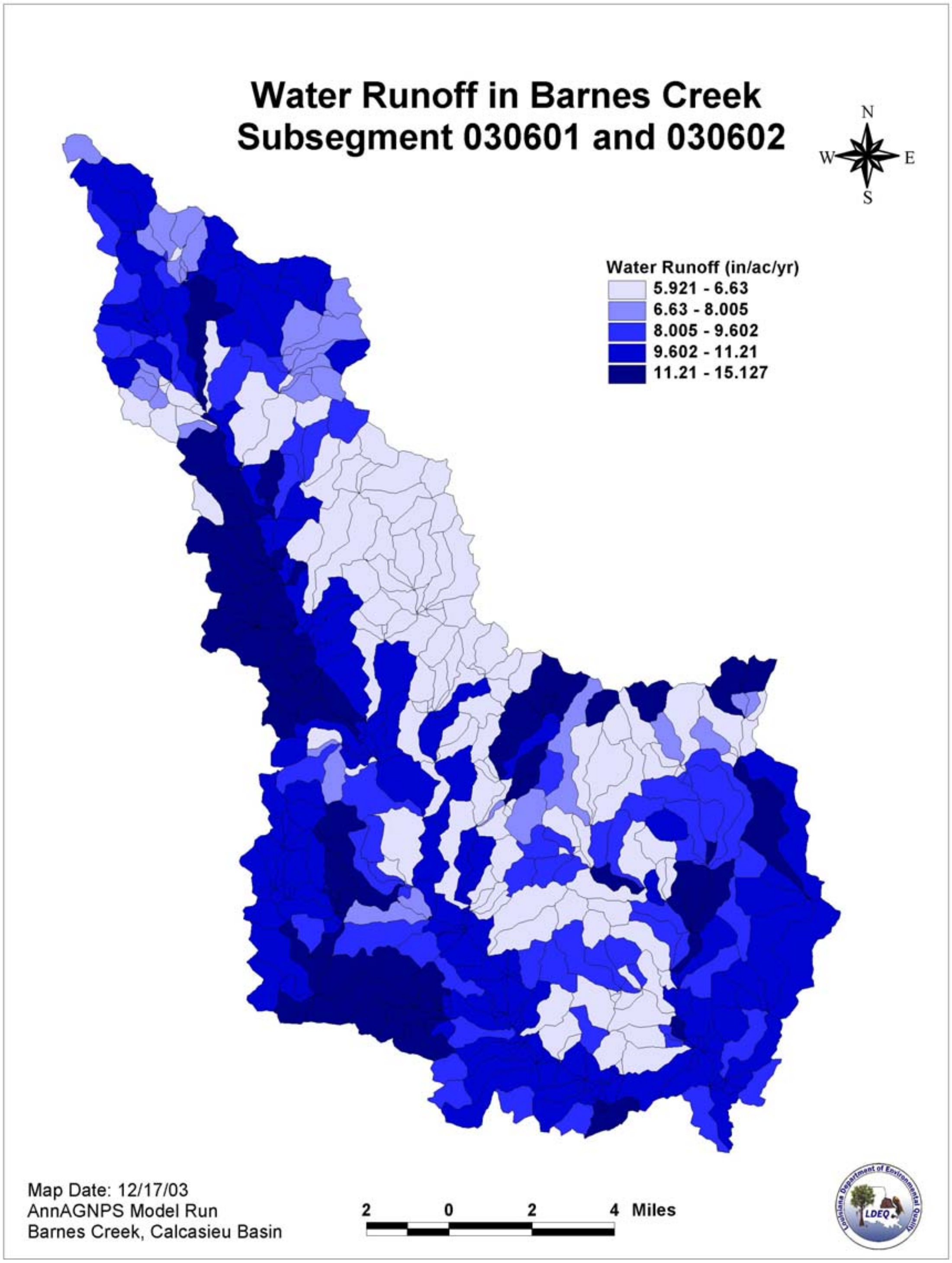


Figure 30. The figure above illustrates the hydrologic cycle. When rainfall falls on land, the water can follow several pathways. Some of the water will remain attached to vegetation and soil and soon evaporate after rainfall. Some of it is taken up by the roots of the plants and is evaporated through the leaves, a process called transpiration. Some of the rainfall will infiltrate into the soil where it migrates laterally toward a stream, a process called interflow. The water will also infiltrate into a permanent groundwater system. During heavy rainfall event, water will migrate overland to local waterbodies. Illustration and text provide by Drever, J.I. 1997.

Water runoff is influenced by a number of factors including soil chemical and physical properties, presence of impermeable surfaces, slope of the land, climate, type of vegetative cover, and root mass. Based on many of these factors (figure 30), AnnAGNPS estimates the average annual amount of water (in/ac/yr) running off of the cells.

The model estimates that some cells are experiencing runoff amounts in excess of 11 in/ac/yr (figure 31). The stream reaches in these areas may be experiencing bed and bank erosion along the stream network. In watersheds with large areas of impervious surfaces, upward of 50% of the sediment load can be attributed to stream erosion. In this case, water rushes overland and scours existing streambeds. Hydraulic modifications to bayous and rivers can also create an unstable system.

Figure 31. Water Runoff from Barnes Creek



6.4 Soil Erodibility K-Factor

When planning for soil conservation and water management, it is important to understand that all soils are not the same and that some are more susceptible to erosion than others. The Revised Universal Soil Loss Equation (RUSLE) can be used to predict soil loss and the effectiveness of management practices. One of the factors used in the RUSLE is the K factor. The K factor is a numeric value attributed to the susceptibility of a soil to sheet and rill erosion. The K value for specific soils can be found in parish soil survey books published by the United States Department of Agriculture (USDA). Values for K range from 0.02 to 0.64 with soils having higher values being more susceptible to sheet and rill erosion. In Barnes Creek Watershed, K values range from 0.304 to 0.466 (figure 32)

6.5 Slope Length and Steepness Factor (LS-Factor)

An important tool for determining the effect of topography on soil loss is the slope length and steepness factor (LS factor). LS values are not absolute values, but represent the ratio of soil loss in a specific area to a value of 1.0 that is given to a slope with 9% steepness and is 72.6 ft long. LS factors are utilized as part of the RUSLE soil erosion equation and can be generated by AnnAGNPS for each cell to determine areas that have high potential for soil erosion. LS values in Barnes Creek watershed range from 0.045 to 3.664 (figure 33).

6.6 Soils Summary

The areas in Barnes Creek Watershed that appear to be of highest concern based upon sediment, soil, and water maps, include an area along the southwestern border of the watershed, an area north of Edith, and the western part of the portion of Allen Parish that is in Barnes Creek Watershed. These areas are also similar to the reaches the TMDL model indicates have the highest amount of nonpoint loading when compensations are made for reach width (figure 9).

Figure 32. K Values in Barnes Creek Watershed

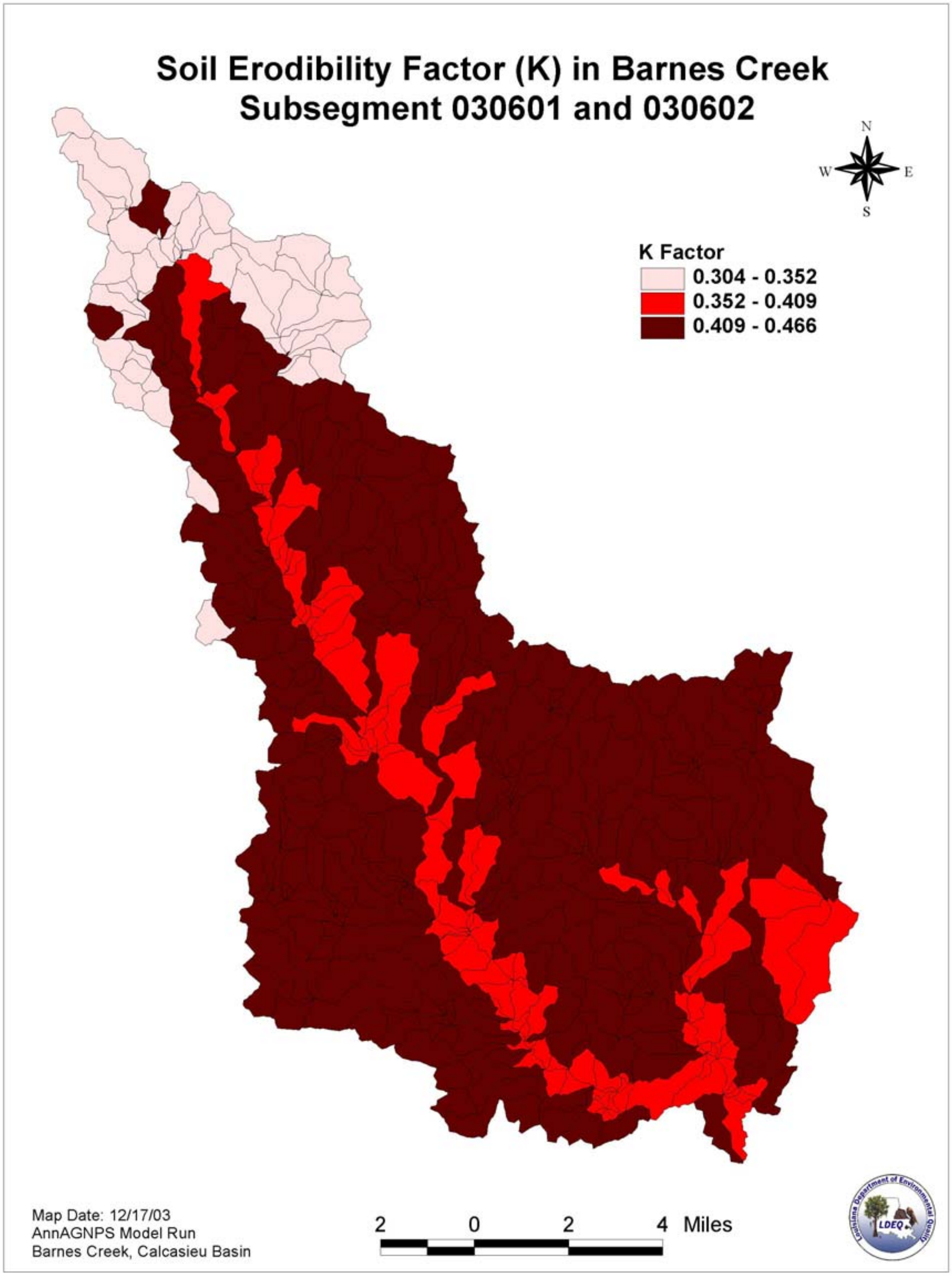
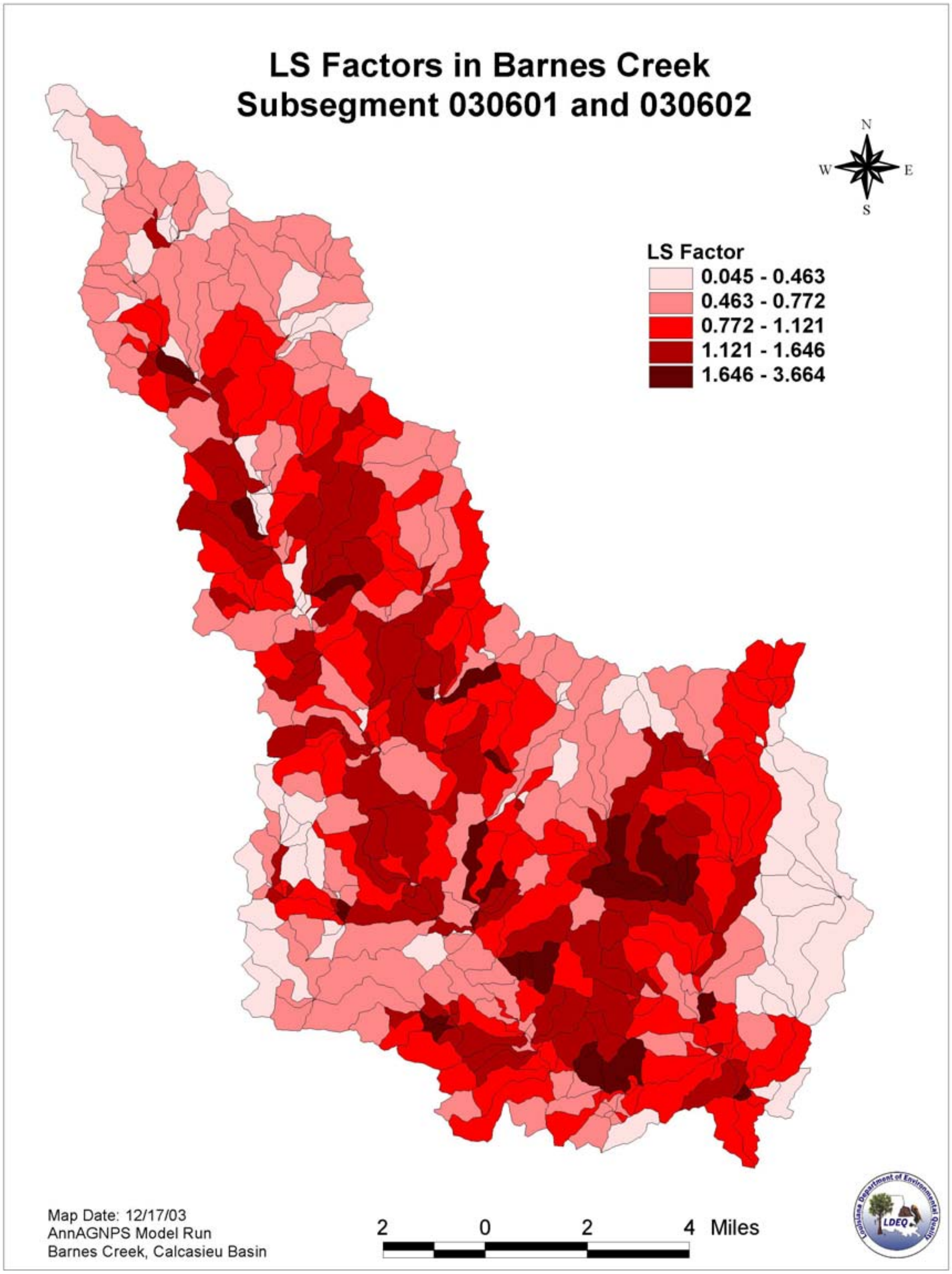


Figure 33. LS Factors in Barnes Creek Watershed



6.7 Nutrients and Organic Carbon

Although nutrients are necessary to plant growth in a water body, over-enrichment leads to excessive algae growth, an imbalance in natural nutrient cycles, changes in water quality and a decline in the number of desirable fish species. Nutrients may reach surface water when soil particles they are adsorbed to are eroded or when the nutrients are dissolved in runoff water. Factors influencing nutrient losses are precipitation, temperature, soil type, land use, and soil chemical and biochemical reactions. Chronic symptoms of over-enrichment include low dissolved oxygen, fish kills, murky water, and depletion of desirable flora and fauna. Excessive amounts of nutrients can also stimulate the activity of microbes, such as Pfisteria, which may be harmful to human health.

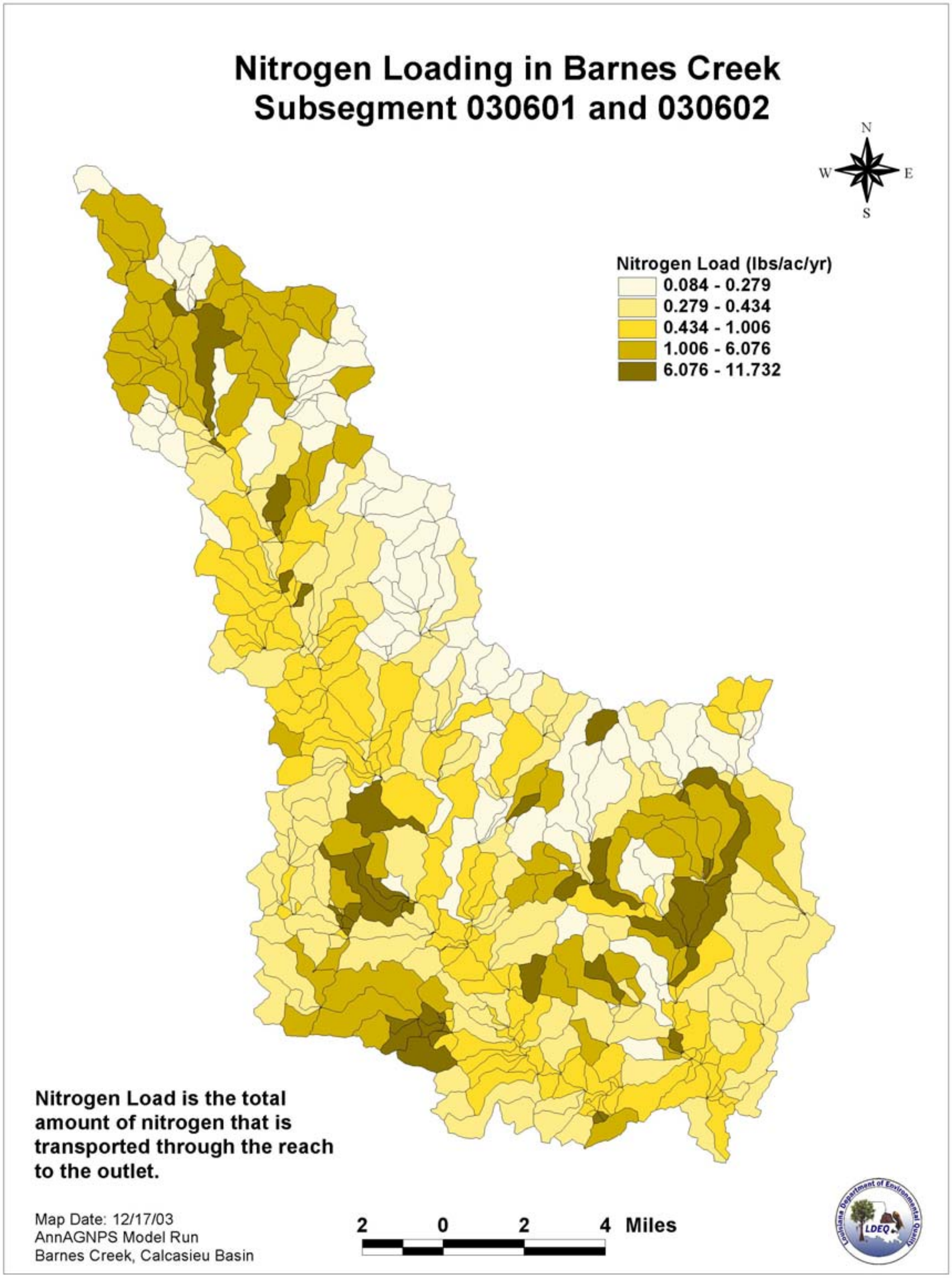
6.8 Nitrogen

Organic nitrogen is the nitrogen incorporated into organic compounds, primarily unassimilated proteins. Bacterial action on such organic matter results in its degradation and the release of ammonia (NH_3). The NH_3 may then be further oxidized to nitrite (NO_2^-) by bacteria such as *Nitrosomonas,* and the NO_2^- produced from this reaction can be oxidized to nitrate (NO_3^-) by other bacteria such as *Nitrobacter.* These biologically mediated reactions are collectively referred to as *nitrification.* In areas subject to reasonably fast currents, the dilution of nitrogen occurs down current and oxidation of ammonia to nitrate prevents accumulation of soluble nitrogenous wastes in the water column.

In aquatic systems excessive concentrations of nitrogen compounds result in both direct and indirect problems. The primary adverse effects are as follows: 1. Organic nitrogen compounds can be mineralized in aquatic systems which results in a loss of dissolved oxygen from the water. 2. In instances where nitrogen is limiting to growth in a particular aquatic ecosystem, discharge of nitrogen compounds can promote the growth of nuisance plankton and algae. 3. When ingested, NO_3^- can be transformed to NO_2^- and result in Methemoglobinemia (Blue Baby Syndrome). 4. Both NH_3 and NO_2^- are toxic to some aquatic species.

Nitrogen loading in Barnes Creek Watershed is generally the highest in the same portions of the watershed that are noted in the soils summary as being areas of high concern. Nitrogen loading ranges from 0.084 to 11.732 lbs/ac/yr in Barnes Creek Watershed (figure 34)

Figure 34. Nitrogen Loading in Barnes Creek Watershed



6.9 Nitrogen Biochemical Oxygen Demand

Nitrogen is important in water quality assessments for reasons other than its role as a nutrient. For example, the oxidation of NH_3 to NO_3^- during the nitrification process consumes oxygen and may represent a significant portion of the total BOD. Stoichiometrically, 3.43 g of oxygen are consumed for each gram of ammonium-nitrogen oxidized to nitrite-nitrogen. During the second stage of nitrification, the nitrobacter bacteria oxidize nitrite to nitrate and 1.14 g of oxygen are consumed per gram of nitrite-nitrogen oxidized. If the two reactions are combined, the complete oxidation of ammonia can be represented by:

$$NH_4^+ + 2\,O_2 \rightarrow N_O{}^3\text{-} + H_2O + 2H^+$$
$$(14\text{ g})\ (64\text{ g})$$

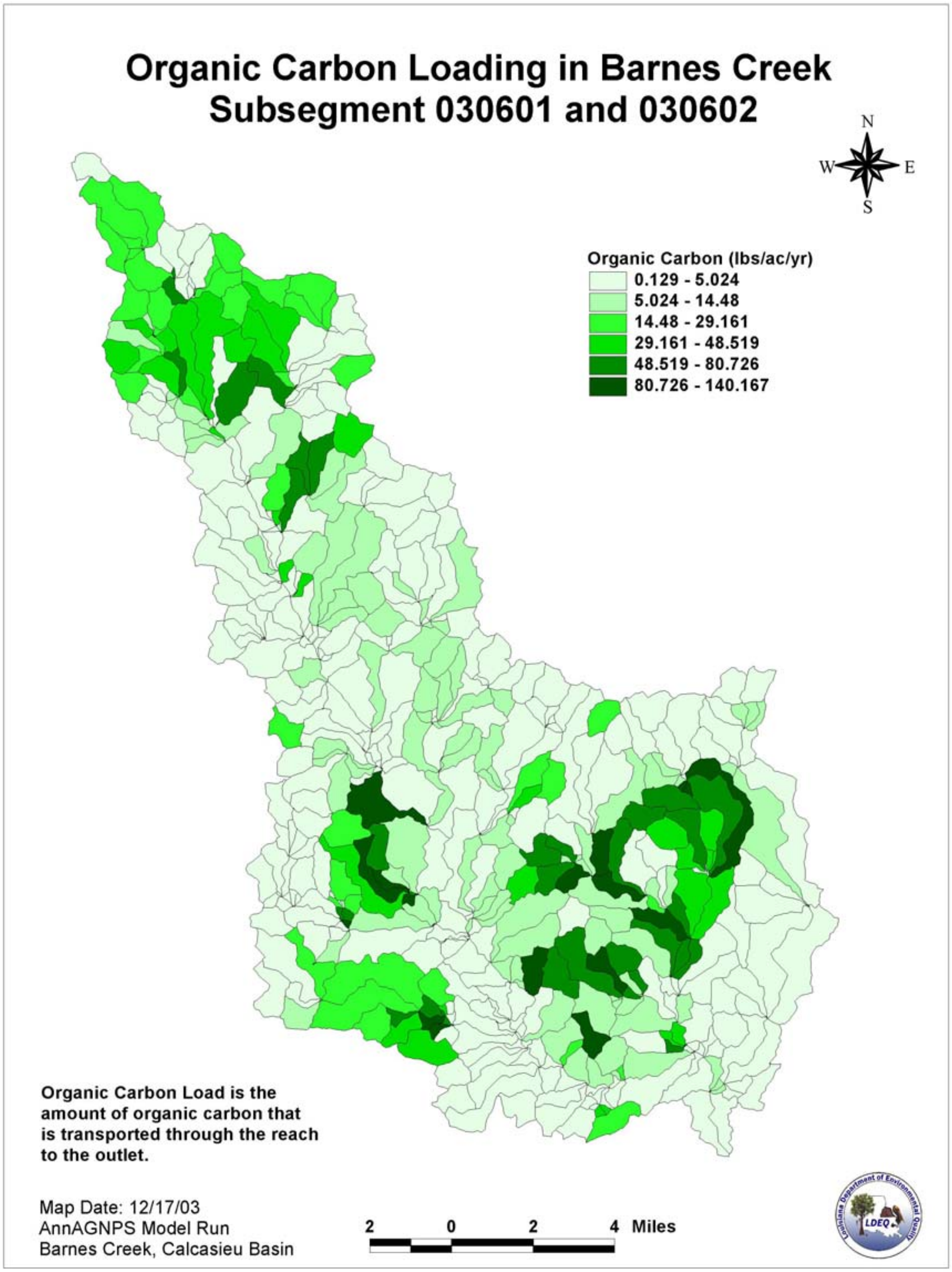
As seen, 64/14 or 4.57 g of oxygen are required for the complete oxidation of one gram of ammonia. In the reactions above, the organic-nitrogen form does not appear, since organic-nitrogen is hydrolyzed to ammonia, and does not consume oxygen in the process.

6.10 Organic Carbon

BOD in Louisiana waterways and sediments is largely composed of Carbonaceous BOD (CBOD). Animal waste, crop debris, oil and grease from roadways and boats, sewage, lawn clippings, and natural sources of plant and animal material all have the potential to enter water bodies and place an oxygen demand on them upon decomposition. If dissolved oxygen levels decrease to low levels and remain low, fish and other aquatic species can die. Often this occurs on a seasonal basis in Louisiana, during periods of low flow and warm water.

Organic carbon loading in Barnes Creek Watershed (figure 35) is similar to nitrogen loading and the areas of high concern noted in the soils summary.

Figure 35. Organic Carbon Loading in Barnes Creek Watershed



6.11 PHOSPHORUS

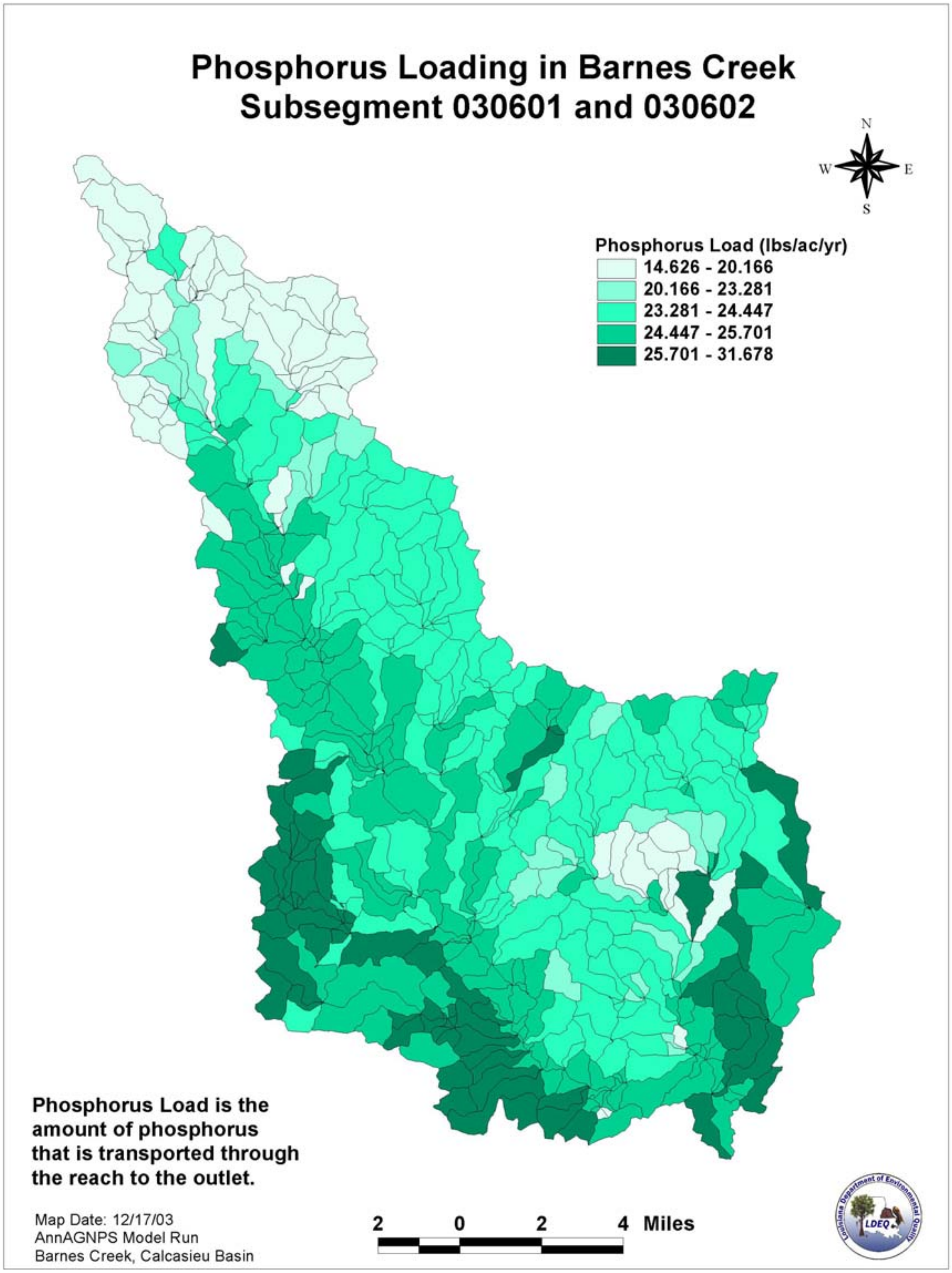
Phosphorus is typically the most limited nutrient in freshwater systems for plant growth. Therefore, when it is introduced to phosphorus limited water, algal blooms can occur. Algae consume dissolved inorganic phosphorus and convert it to the organic form. When the algae die and decompose, dissolved oxygen in the water can decrease and result in fish kills.

Natural sources of P in water include leaching from phosphate-bearing rocks and organic matter decomposition. Runoff and erosion can carry additional phosphorus to water bodies in the form of manmade fertilizers, domestic sewage, animal manure, and detergents. Numerous Phosphorus compounds exist in soil, but most are insoluble. Dissolved inorganic phosphorus (orthophosphate) is the major form of P directly available to algae. Phosphorus in forms that have very low solubilities that get washed into water bodies may later be released and become available to algae if the water chemical properties, such as pH, change.

Total P levels in unpolluted waters are usually less than 0.1mg per liter and inorganic (orthophosphate) soluble P is often less than 0.01 mg per liter (Lind, 1979). Phosphorus is rarely found in concentrations that are toxic to higher organisms.

Phosphorus loading in Barnes Creek Watershed appears to be of highest concern along the western and southern edges of the watershed (figure 36).

Figure 36. Phosphorus Loading in Barnes Creek Watershed.



7.0 WATERSHED LAND USES

Nonpoint source pollution comes from various sources within a watershed including agriculture, forestry, urban runoff, construction, hydromodification, home sewage and resource extraction. Practices that result in the exposure of bare soil to precipitation events result in greater runoff than land that has a healthy root system and dense canopy cover. Forested and pasture areas generally have lower loading rates than bare or tilled ground.

Land uses from 2003 are summarized in table 7. The two primary land uses in Barnes Creek Watershed are forest (76,907 acres) and pasture (48,074 acres). Subsegment 030601 (figure 37) appears to have a higher proportion of agriculture related activities and subsegment 030602 (figure 38) has a higher proportion of forested land. Nutrient loading from forestry and agriculture can be mitigated by the use of Best Management Practices (BMPs). Road construction along highways, such as the current project to expand highway 171 to include 4 lanes, is another potential source of sediment loading to the watershed.

Table 7. Land uses in Barnes Creek Watershed

Land Cover	Subseg 030601 (acres)	Subseg 030601 (%)	Subseg 030602 (acres)	Subseg 030602 (%)	Total Acres	Total %
Water	15	0.13	178	0.15	193	0.15
Pasture - Idle - Hay	5,746	48.31	42,328	36.73	48,074	37.82
Forest	5,707	47.98	71,200	61.79	76,907	60.50
Shrub-Scrub	66	0.56	27	0.02	93	0.07
Aquaculture - Rice	176	1.48	674	0.59	850	0.67
Soybeans	0	0.00	11	0.01	11	0.01
Corn	30	0.25	0	0.00	30	0.02
Urban	3	0.03	96	0.08	99	0.08
Bare	151	1.27	689	0.60	840	0.66
Gravel Operation			27	0.02	27	0.02
TOTAL	11,894	100	115,230	100	127,124	100.00

Figure 37. Land Use in Upper Barnes Creek Watershed

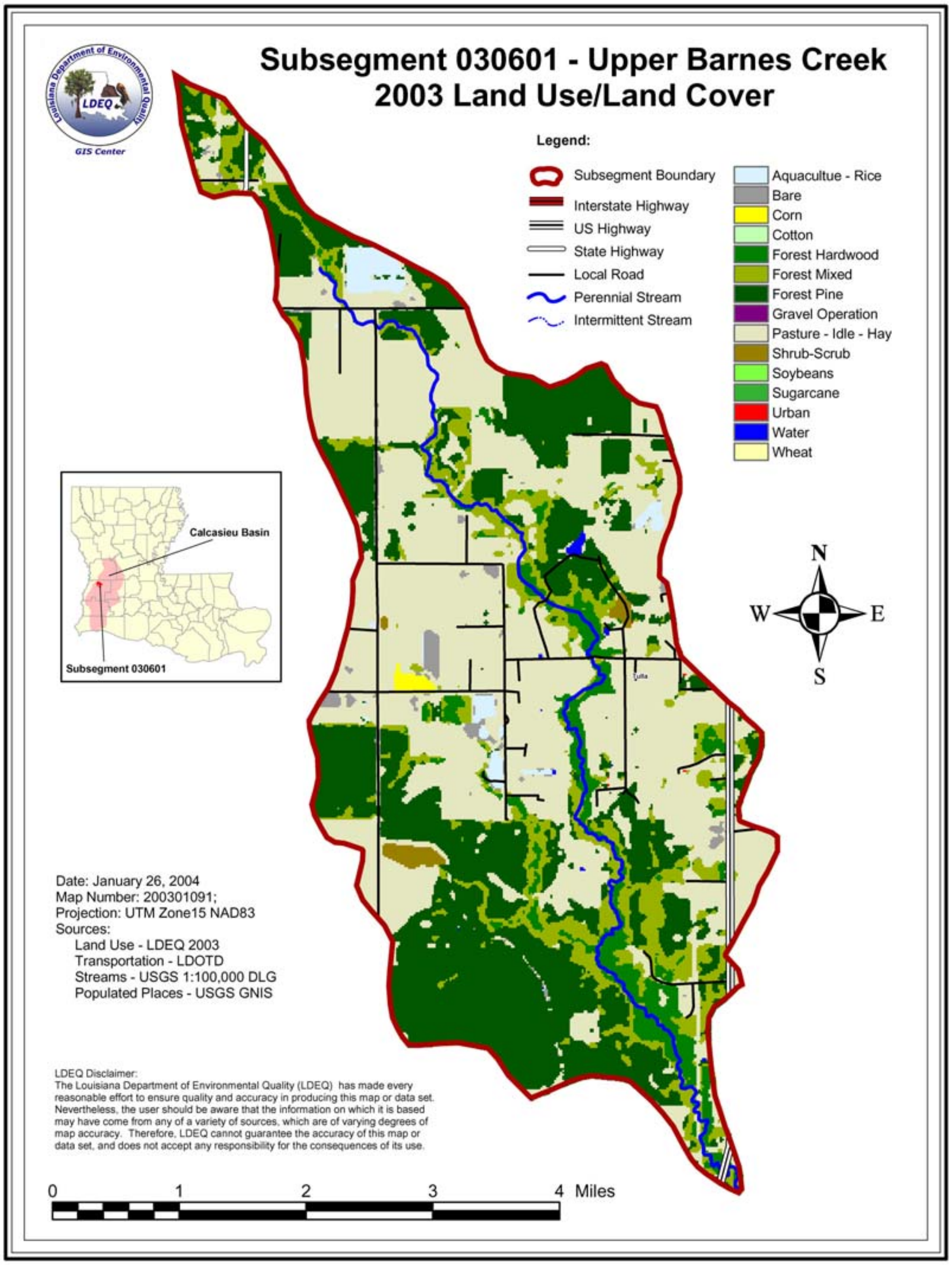
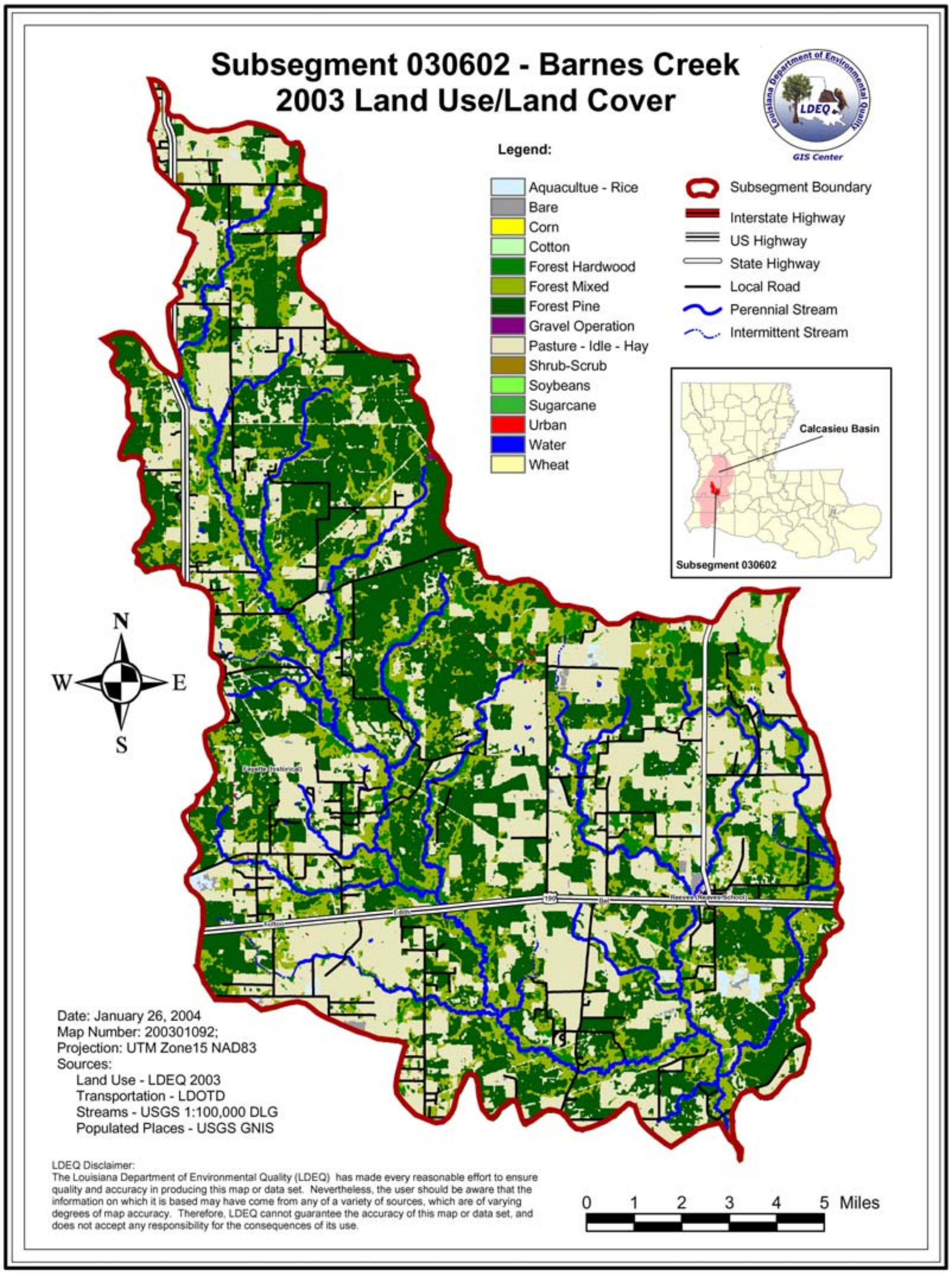


Figure 38. Land Use in Lower Barnes Creek Watershed



7.1 STATE HIGHWAYS

Image 5. Runoff from Hwy 190 leaves a visible oily scum on the water surface at Clear Creek.

Runoff from highways at bridges and stream crossings is a statewide nonpoint source pollution issue. Barnes Creek is a good example of a watershed where water quality is visibly affected by the presence of a major highway. State highway 190 has a relatively high traffic load, and runoff from the bridges currently enter the tributaries of Barnes Creek without any form of treatment or detention. Runoff from roadways may contain oil/grease (hydrocarbons) and heavy metals including lead. During the reconnaissance survey of Barnes Creek, a visible oily sheen was recorded at many of the crossings of Barnes Creek tributaries (image 5).

The Barnes Creek watershed is also traversed by federal highway 171, which runs north and south. Currently a project is underway to widen the roadway to include 4 lanes. Highway construction can increase the risk of nonpoint source pollution by creating bare ground along streams and by disturbing the streambed with equipment (image 6).

Image 6. Construction site on Highway 171.

7.2 PASTURELAND GRAZING

Grazing cattle on pastureland is a common practice. Livestock often seek the shade offered in the riparian zone around streams and use the stream itself as a water source. When livestock are not fenced out of riparian zones, water quality has the potential to decrease.

When allowed inside the riparian zone, livestock can directly degrade water quality in multiple ways. Fecal matter can be deposited into the water adding nutrients and bacteria directly to the stream. The undigested organic material associated with fecal matter also has the potential to decrease DO as bacteria degrade it. Furthermore, the trampling by hooves can collapse stream banks and increase turbidity by churning up the streambed.

Livestock allowed in riparian zones also have the potential to indirectly degrade water quality if not managed properly. Groundcover within the riparian zone can be decreased as a result of overgrazing and from being trampled by hooves. The loss of groundcover results in unstable banks that can be easily eroded and fill streambeds in with sediment.

The loss of groundcover also decreases the filtering capabilities of the riparian zone. Maintaining quality riparian zones in pasturelands is especially important for filtering sediment, fertilizers, and pesticides out of runoff.

Convincing producers to reduce livestock access to the Barnes Creek and riparian zones should help improve water quality. Furthermore, as the current trend in South Louisiana is to convert cropland to pastureland, it is important for producers to be aware of the water quality issues associated with livestock production and install BMPs before cattle are stocked. These measures should help prevent further degradation of water quality in Barnes Creek Watershed.

7.3 AGRICULTURE

Common agricultural practices, such as tillage and chemical applications, can both directly and indirectly affect water quality. Tilled soil is void of vegetation which can hold it in place and is therefore more susceptible to being washed away by rainfall and ending up in waterbodies. Soil tillage can also affect soil bulk density and reduce soil moisture content, each of which can affect the microorganisms needed to convert nutrients into plant available forms. Furthermore, tillage can delay infection of arbuscular mycorrhiza, which has been shown to transfer P, N, ZN, C, and S to plants. Plants grown with reduced arbuscular mycorrhiza infection due to tillage have been shown to have lower P uptake and lower yields relative to no till (Paul and Clark, 1989). Reduced P uptake is of importance because excess soil P is readily transported in runoff as dissolved P or attached to soil particles. Therefore, soil practices that help keep soil particles from washing away, such as no till, are beneficial in both improving crop production and in reducing nonpoint pollution.

Management practices for rice are different than those for the other agronomic crops. One of the major problems rice producers face is control of red rice. Red rice is closely related to commercial rice and many pesticides that kill red rice also kill commercial rice. Therefore, management practices, such as water seeding, are often used to control red rice. When water seeding, the flooded rice field is tilled to muddy the water and to kill germinated red rice that would otherwise emerge through the clear water. The muddy water is released from the rice fields in April and can contribute sediment and nutrients to waterbodies. Since water seeding is primarily done to control red rice, advances made in red rice control could decrease water seeding and therefore reduce nonpoint load.

It should also be noted that rice production also has the potential to increase dissolved oxygen in watersheds. Since rice grows best when its roots are submerged, the plants are grown in flooded fields. Sediment has time to settle out of this water during the growing season and the rice growth keeps DO in the water high. This good water is periodically released during the growing season and right before harvest in July and again in October and can result in increased DO in the receiving waterbodies.

7.4 Forestry

Undisturbed forestland can benefit water quality. Trees along stream banks can shade the water and decrease water temperature. Trees can also help trap sediment runoff and stabilize stream banks. However, when forests are harvested or planted using improper techniques, water quality can suffer. Improper forest management can result in increased amounts of sediment and nutrients being transported to the streams and altered flow patterns due to debris in the streams and improper water crossings

7.5 Sites of Special Scientific Interest

Image 7. Yellow Pitcher Plants (Sarracenia alata) on Redhead Reach Drive.

The Barnes Creek watershed includes acidic bogs in the pine forest areas, which may be colonized by rare indigenous plants such as the yellow pitcher plant (image 7). This picture serves as a reminder that some of the riparian vegetation, which helps to preserve water quality, may also have other intrinsic value.

8.0 POINT SOURCES OF POLLUTION

The City of DeRidder was the only significant discharger in Barnes Creek Watershed. This discharger is located in subsegment 030601. The seasonal summer dissolved oxygen standard for this subsegment is 2.0 mg/l because this reach is intermittent. No reductions in permit limits for the City of DeRidder are required to maintain this seasonal standard.

Three additional dischargers fall within Barnes Creek watershed. These facilities were deemed either intermittent stormwater or minor discharges on unnamed tributaries and were not included as point sources in the model.

9.0 BEST MANAGEMENT PRACTICES

Best management practices (BMPs) are "schedules of activities, prohibitions of practices, maintenance procedures and other management practices designed to prevent or reduce the pollution of the waters of the state, including treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge, or waste disposal, or drainage from raw material storage" (LDEQ 2003). BMPs are one of the most important methods for controlling nonpoint source pollution where runoff occurs from diffuse sources making regulations in the form of discharge permits unpractical.

Many entities have been involved in recommending the most effective and up-to-date BMP practices possible. These BMP practices are often the culmination of years of research and demonstrations conducted by agricultural research scientists and soil engineers (LSU Agricultural Center, 2000). A summary of the effectiveness of favorable BMPs is provided in Louisiana's Nonpoint Source Management Plan (LDEQ, 2000).

For Barnes Creek, BMPs need to be implemented to reduce manmade nonpoint pollution by 70% and increase the D.O. to levels that comply with the standards and allow it to support its designated uses. As previously indicated, reducing runoff from construction sites is a primary concern in Barnes Creek Watershed. Effective BMPs for construction activities include diversion dikes, vegetative buffer strips, seeding and mulching, hay bale dikes, silt fencing, vegetative cover, sediment basins, and sediment traps (http://nonpoint.deq.state.la.us/). LSU AgCenter has produced BMP manuals for agronomic crops, rice, poultry, sugar cane, dairy, sweet potato, swine, beef, and aquaculture which are available on their website (http://www.lsuagcenter.com/Subjects/bmp/index.asp). For all entities involved in silvicultural operations, the "Recommended Forestry Best Management Practices for Louisiana" manual has been and will continue to be an invaluable source of information and recommendations (Louisiana Department of Environmental Quality, 2000). Appendix 2 contains a list of BMP sources.

Additionally, as technology advances, certain farming practices and BMPs may gradually become obsolete or replaced by other methods. For example, the recent development, through genetic engineering, of herbicide resistant rice may change the way that rice is produced in Louisiana (Williams et. al, 2002). If the practice of "mudding in" were no longer needed to control red rice, a significant decrease in the nonpoint source load would be expected. Also, a reduction in the quantity of water used would likely result.

10.0 ACTIONS TO BE IMPLEMENTED BY LDEQ

The LDEQ is presently designated the lead agency for implementation of the Louisiana Nonpoint Source Program. The LDEQ Nonpoint Source Unit provides USEPA §319(h) funds to assist in implementation of BMPs and to address water quality problems on subsegments listed on the §303(d) list. USEPA §319(h) funds are utilized to sponsor cost sharing, monitoring, and education projects. These monies are available to all private, for profit, and nonprofit organizations that are authenticated legal entities, or governmental jurisdictions including: cities, counties, tribal entities, federal agencies, or agencies of the State. Presently, LDEQ is cooperating with such entities on approximately 60 nonpoint source projects that are active throughout the state.

11.0 ACTIONS TO BE IMPLEMENTED BY OTHER AGENCIES

The U.S. Department of Agriculture (USDA) and Natural Resource Conservation Service (NRCS) offer landowners financial, technical, and educational assistance to implement conservation practices and/or BMPs on privately owned land to reduce soil erosion, improve water quality, and enhance crop land, forest land, wetlands, grazing lands and wildlife habitat. The 2003 Farm Bill provides funding to various conservation programs for each state by way of the NRCS and local Soil and Water Conservation Districts (SWCD). The following includes a brief summary of the programs available through the local SWCD under the oversight of USDA and NRCS. The descriptions of the programs are general and are subject to change.

2003 FARM BILL CONSERVATIONS PROGRAMS AND POTENTIAL FUNDING SOURCES.

Environmental Quality Incentive Program (EQIP) provides 75% - 90% cost share for environmentally beneficial structural and management alterations, primarily 60% to livestock operations. Applications prioritized for benefits. Considered the "Working Lands" program.

Wildlife Habitat Incentive Program (WHIP) provides 75% - 90% cost share for the costs of wildlife habitat restoration and enhancement on private lands. Eligible to private property owners and lessees for installing riparian buffers, native pine & hardwoods, wildlife corridors, and other wildlife enhancing measures, 5 – 10 year contracts.

Wetland Reserve Program (WRP) is a voluntary program for wetland restoration, enhancement, and protection on private lands. WRP provides annual payments and restoration costs for 10 year, 30 year, or perpetual easements on prior converted wetlands. Louisiana leads the US in WRP participation. 2002 Farm Bill total funding allocation is

1.5 billion and expanded the program to purchase long-term easements and cost sharing to agriculture producers.

Conservation Reserve Program (CRP)
The 1985 Farm Bill established CRP as a voluntary program to protect highly erodible and environmentally sensitive lands. CRP places a positive value on rural environment by improving soil, water, and wildlife, and extends a pilot sub-program called the Conservation Reserve Enhancement program

Conservation Security Program (CSP) is a new national incentive payment program for maintaining and increasing farm and ranch stewardship practices. The CSP is designed to correct a policy disincentive in which independently conducted resource stewardship has disqualified many farmers from receiving conservation program assistance. CSP features an optional "tiered" level of farmer participation where higher tiers receive greater funding for greater conservation practices.

Farmland Protection Program (FPP) provides funding to states, tribes, or local governments and to nonprofit organizations to help purchase development rights and protect farmlands with prime, unique, or productive soil; historical or archaeological significance; or farmlands threatened by urban sprawl. Louisiana does not currently have any FPP contracts.

Grassland Reserve Program (GRP) is a new program to enroll up to 2 million acres of virgin and improved pastureland. GRP easements would be divided 40/60 between agreements of 10, 15, or 20-years and agreements and easements for 30-years and permanent easements to restore grassland, rangeland, and pasture through annual rental payments.

Small Watershed Rehabilitation Program (SWRP) provides essential funding for the rehabilitation of aging small watershed impoundments and dams that have been constructed over the past 50 years.

In addition to the programs mentioned, the following organizations have signed an MOU with LDEQ within the state's NPS Management Plan that each will aid LDEQ in achieving the goals of the management plan:

Louisiana Department of Agriculture and Forestry
Louisiana Department of Health and Hospitals
Louisiana Department of Wildlife and Fisheries
Louisiana Department of Transportation and Development
Louisiana Department of Natural Resources
Louisiana State University Agricultural Center
Natural Resources Conservation Service
USDA – Farm Services Agency
Louisiana Forestry Association

US Fish and Wildlife Service
USDA Forest Service
US Army Corps of Engineers
US Geological Survey
Federal Emergency Management Agency
Louisiana Farm Bureau Federation

MASTER FARMER PROGRAM

The Master Farmer Program (developed by Louisiana State University Agricultural Center) is to encourage on-the-ground BMP implementation with a focus on environmental stewardship. The LSU AgCenter is promoting the Master Farmer Program to help farmers address environmental stewardship through voluntary, effective, and economically achievable BMPs. The program will be implemented through a multi-agency/organization partnership including the Louisiana Farm Bureau (LFBF), the Natural Resources Conservation Service (NRCS), the Louisiana Cooperative Extension Service (LCES), USDA-Agriculture Research Service (ARS), LDEQ, and agricultural producers.

The Master Farmer Program has three components: environmental stewardship, agricultural production, and farm management. The environmental stewardship component has three phases. Phase I focuses on environmental education and implementation of crop-specific BMPs. Phase II of the environmental component includes in-the-field viewing of implemented BMPs on Model Farms. Phase III involves the development and implementation of farm-specific, comprehensive conservation plans by the participants. A member must participate in all three phases in order to gain program status and receive the distinction of being considered a master farmer.

This program can help to initiate and distribute the use of BMPs throughout Barnes Creek Watershed. Participants will set an example for the rest of the agricultural community and will work closely with NRCS staff and other Master Farmers to identify potential problem areas in the watershed. They will receive information on new and innovative ways to reduce soil and nutrient loss from their fields. They will be kept informed of the water quality monitoring occurring in the watershed and alerted of any degradation or improvements.

MASTER LOGGER PROGRAM

The master logger program served as a model for development of the master farmer program, and has been very successful at educating foresters as to BMP implementation. This program was developed by the Louisiana Forestry Association, which is a private organization, along with the Louisiana Department of Agriculture and Forestry Office of Forestry.

12.0 CONSERVATION PRACTICES IN BARNES CREEK WATERSHED

Although information is not currently available for conservation treatments specifically in Barnes Creek Watershed, they are available for Beauregard and Allen parishes which is where the watershed is located. It is reported that 15,936 acres in these two parishes were engaged in conservation treatments through programs, such as EQIP, WHIP, CRP, and WRP, during fiscal year 2003 (NRCS PRMS Report). This includes total conservation buffers, erosion reduction, irrigation water management, nutrient management, pest management, prescribed grazing, residue management, tree and shrub establishment, and wildlife habitat.

13.0 PUBLIC PARTICIPATION OF STAKEHOLDERS

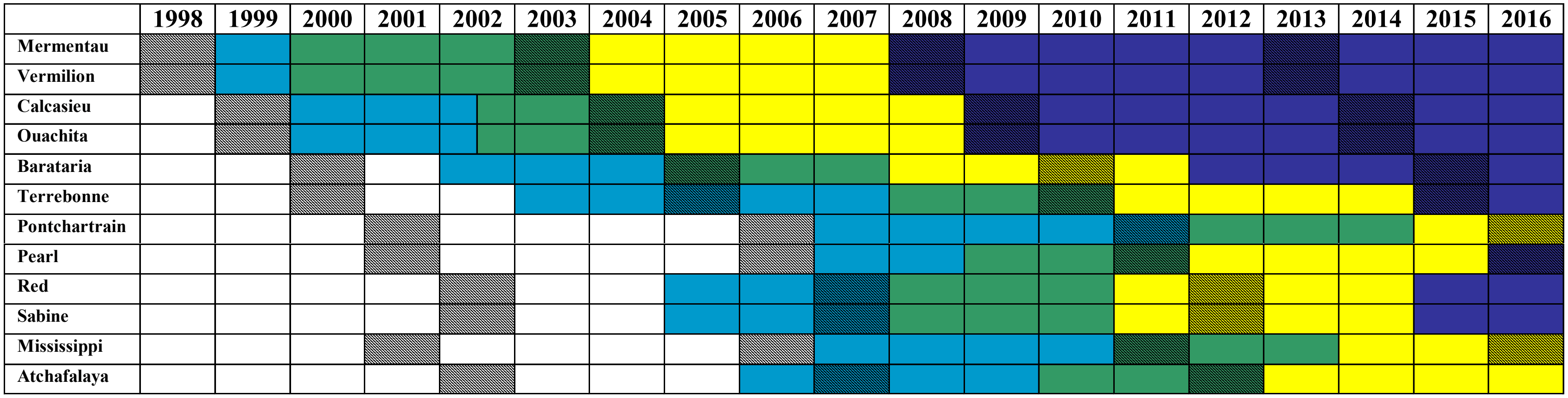
Presently, the only requirement for public participation is that there be a 30–day comment period after the TMDL is issued. Therefore, stakeholders are informed by mailed public notices and notices in newspapers. Ultimately, the public needs to be the most important part of the implementation of TMDLs, especially in the arena of nonpoint source pollution where there are few regulations. This is one of the areas where programs such as Master Farmer will be beneficial in getting information to landowners and farmers and building participation.

14.0 TMDL TIMELINE FOR THE NPS IMPLEMENTATION PLAN

The NPS Implementation Plan for Barnes Creek Watershed outlines a 5-year management plan to reduce NPS pollutants reaching the waterway. LDEQ intensively samples each watershed in the state once every 5 years to see if the waterbodies are meeting water quality standards. The 5-year cyclic sampling began during 1999 for the Calcasieu Basin, including Barnes Creek, and will occur again in 2004, 2009, and 2014 (Table 8). The data from 1999 will be used as a baseline to measure the rate of water quality improvement in samples taken in subsequent years. If no improvement in water quality is witnessed by the 2009 sampling, LDEQ will revise the NPS Implementation Plan to include additional corrective actions to bring the waterway into compliance. Additional BMPs and or other options will be employed, if necessary, until water quality standards are achieved and Barnes Creek is restored to its designated uses.

Table 8.

Revised Timeline for Watershed Planning and Implementation



1- Black Stripes = Collect Water Quality Data to Develop Total Maximum Daily Loads (TMDLs) and to Track Water Quality Improvement at the Watershed Level **[Objective 1]**
2- Light Blue = Develop Total Maximum Daily Loads for the Watersheds on the 303(d) List [**Objective 2]**
3- Green = Develop Watershed Management Plans to Implement the NPS Component of the TMDL **[Objective 3]**
4- Yellow = Implement the Watershed Management Plans **[Objectives 4-8]**
5- Dark Blue = Develop and Implement Additional Corrective Actions Necessary to Restore the Designated Uses to the Water Bodies **[Objective 9-10]**

15.0 TRACKING AND EVALUATION

As Stated in the Louisiana Nonpoint Management Plan, program tracking will be done at several levels to determine if the watershed approach is an effective method to reduce nonpoint source pollution and improve water quality:

1. Tracking of actions outlined with the Watershed Restoration Action Strategy (short-term)
2. Tracking of BMPs implemented as a result of Section 319, EQIP, or other sources of cost-share ant technical assistance within the watershed (short term);
3. Tracking progress in reducing nonpoint source pollutants, such as solids, nutrients, and organic carbon from the various land uses (rice, soybeans, crawfish farms) within the watershed (short-term);
4. Tracking water quality improvement in the bayou (i.e. decreases in total organic carbon, total dissolved oxygen) (short and long term)
5. Documenting results of the tracking to the Nonpoint Source Interagency Committee, residents within the watershed, and EPA (short and long term);
6. Submitting semi-annual and annual reports to EPA which summarize results of the watershed restoration actions (short and long term)
7. Revising LDEQ's web-site to include information on the progress made in watershed restoration actions, nonpoint source pollutant load reductions, and water quality improvement in the bayou (short and long term).

16.0 REGULATORY AUTHORITY

<u>Federal Authority</u>
Section 319 of the Clean Water Act (PL 100-4, February 4, 1987) was enacted to specifically address problems attributed to nonpoint sources of pollution. Its objective is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters (Sec. 101; PL 100-4), instructed the Governor of each State to prepare and submit a Nonpoint Source Management Program for reduction and control of pollution from nonpoint sources to navigable waters within the State by implementation of a four-year plan (submitted within 18 months of the day of enactment).

<u>State Authority</u>
In response to the federal law, the State of Louisiana passed Revised Statute 30:2011, signed by the Governor in 1987 as Act 272. Act 272 designated the Louisiana Department of Environmental Quality as the "Lead Agency" for development and implementation of the State's Nonpoint Source Management Plan. The Louisiana Revised Statutes R.S. 30:2011.D (20) include the following provision as the authority for LDEQ to implement the State's NPS Program.

To develop and implement a non-point source management and ground water quality protection program and a conservation and management plan for estuaries, to receive federal funds for this purpose and provide matching state funds when required, and to comply with terms and conditions necessary to receive federal grants. The nonpoint source conservation and management plan, the groundwater protection plan, and the plan for estuaries shall be developed in coordination with, and with the concurrence of the appropriate state agencies, including but not limited to, the Department of Natural Resources, the Department of Wildlife and Fisheries, the Department of Agriculture and Forestry and the State Soil and Water Conservation Committee in those areas pertaining to their respective jurisdictions.

LAC 33:IX.1101.D.
The water quality standards described within this chapter are applicable to surface waters of the state and are utilized through the wasteload allocation and permit process to develop effluent limitations for point source discharges to surface waters of the State. These also form the basis for implementing the best management practices for control of nonpoint sources of water pollution.

LAC 33:IX.1109.A.2 Antidegradation Policy
Chapter 11 also states that the administrative authority will not approve any wastewater discharge or certify any activity for federal permit that would impair water quality or use of state waters. Waste discharges must comply with applicable state and federal laws for the attainment of water quality goals. Any new, existing, or expanded point source or nonpoint source discharging into state waters, including land clearing which is the subject of a federal permit application, will be required to provide the necessary level of waste treatment to protect state waters as determined by the administrative authority. Further, the highest statutory and regulatory requirements shall be achieved for all existing point sources and best management practices (BMPs) for nonpoint sources. Additionally, no degradation shall be allowed in high-quality waters that constitute outstanding natural resources, such as waters of ecological significance as designated by the office. Those water bodies presently designated as outstanding resources are listed in LAC 33:IX.1123

17.0 REFERENCES

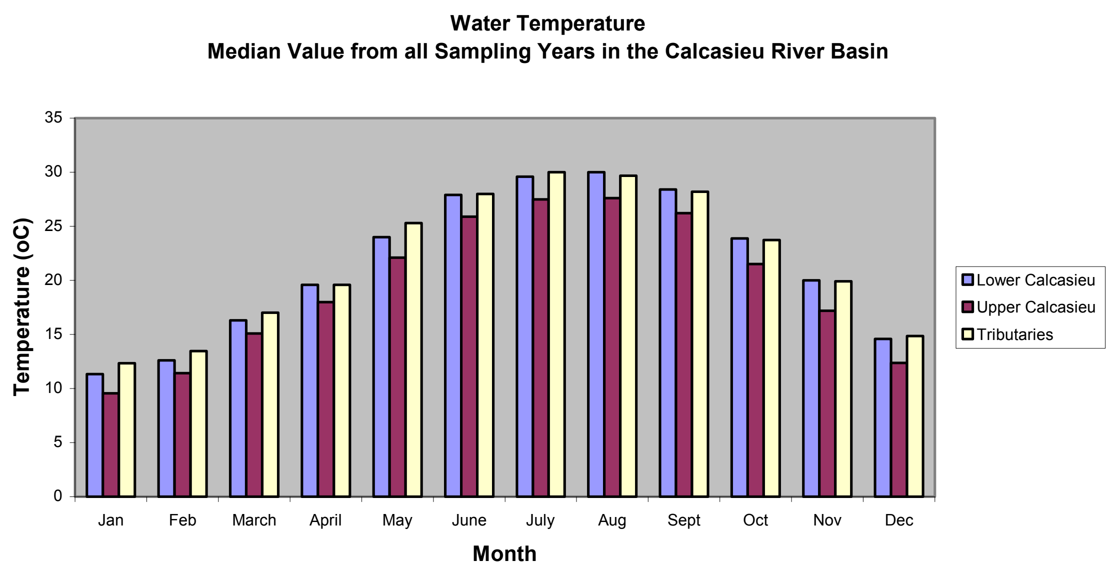
Drever, J.I. 1997. The Geochemistry of Natural Waters: Surface and Groundwater Environments, 3rd ed. Prentice Hall, Upper Saddle River, NJ.

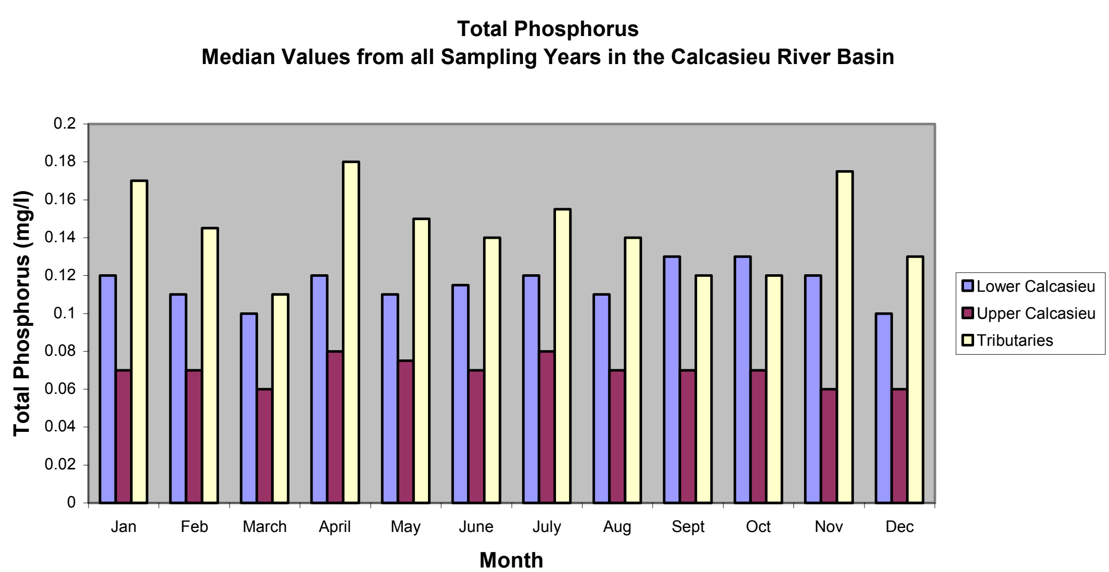
LDEQ. 2003. Environmental Regulatory Code Title 33 Part IX. Water Quality. Baton Rouge, Louisiana, p.2.

Paul, E.A., and F.E. Clark. 1998. Soil Microbiology and Biochemistry. Academic Press, Boston.

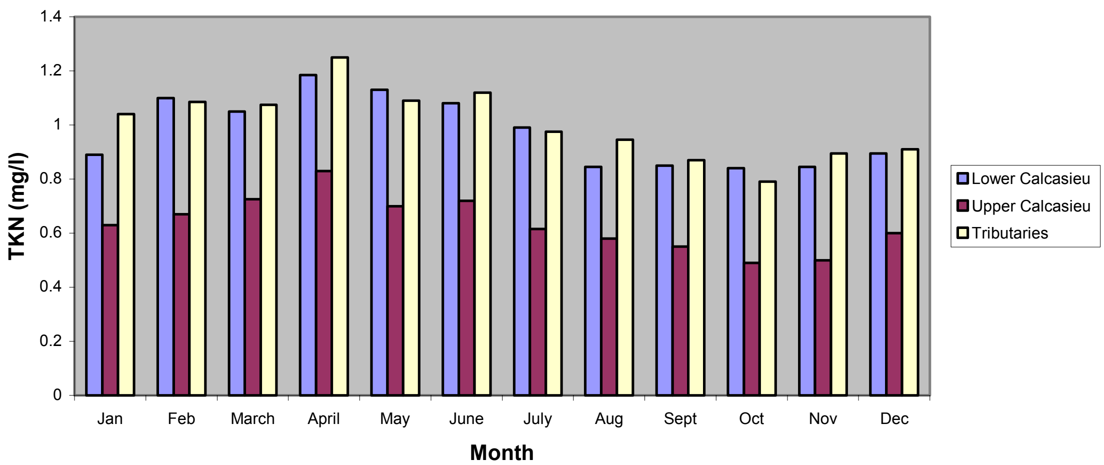
APPENDIX 1

Historic water quality data from the Calcasieu River Basin

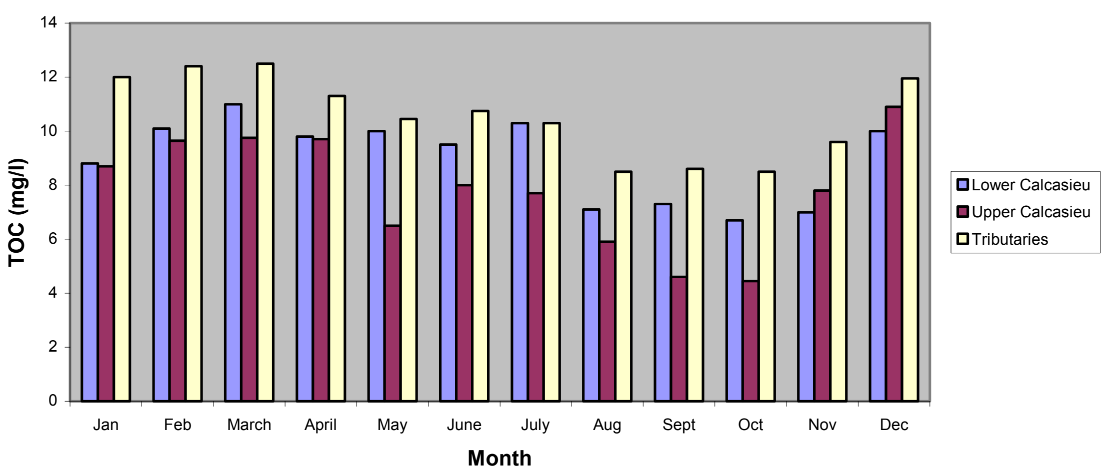




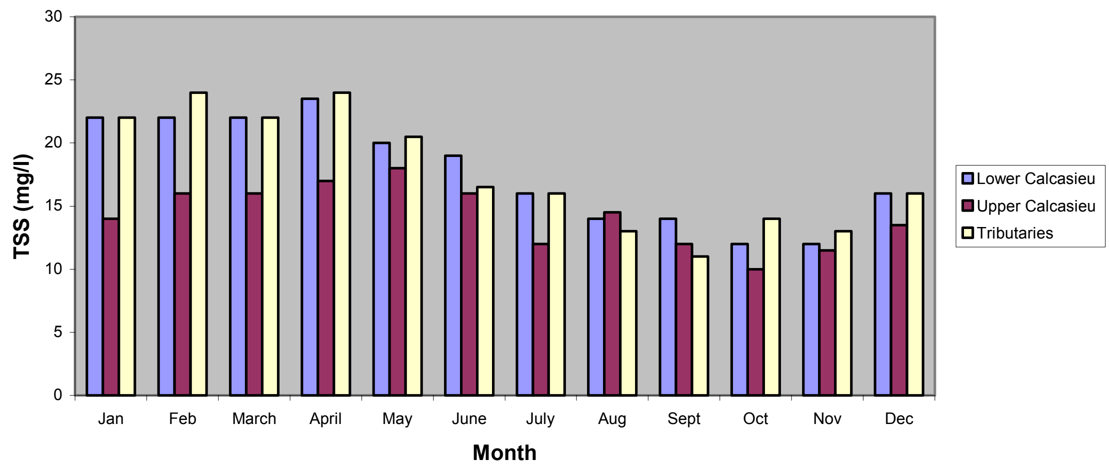
Total Kjeldahl Nitrogen (TKN)
Median Values from all Sampling Years in the Calcasieu River Basin



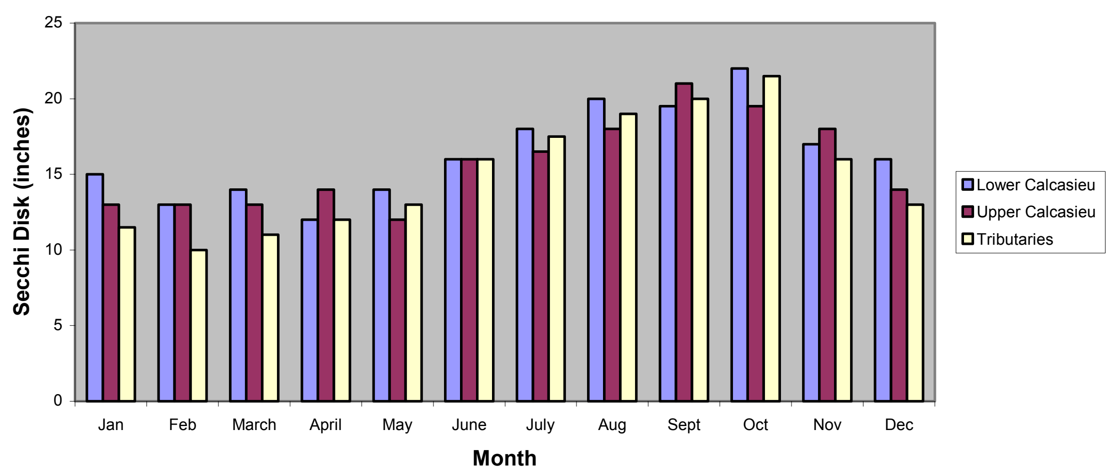
Total Organic Carbon (TOC)
Median Values from all Sampling Years in the Calcasieu River Basin

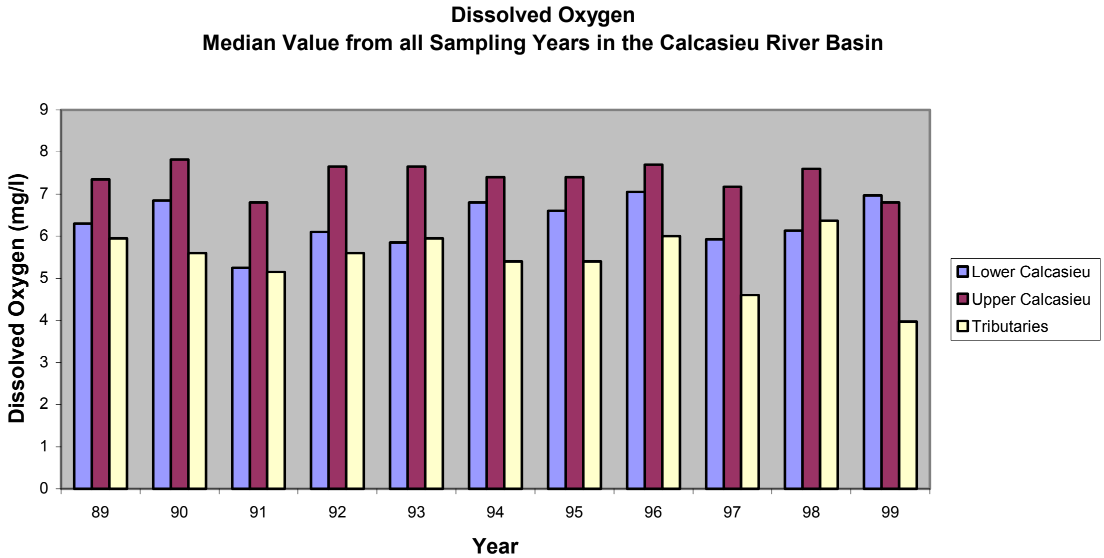


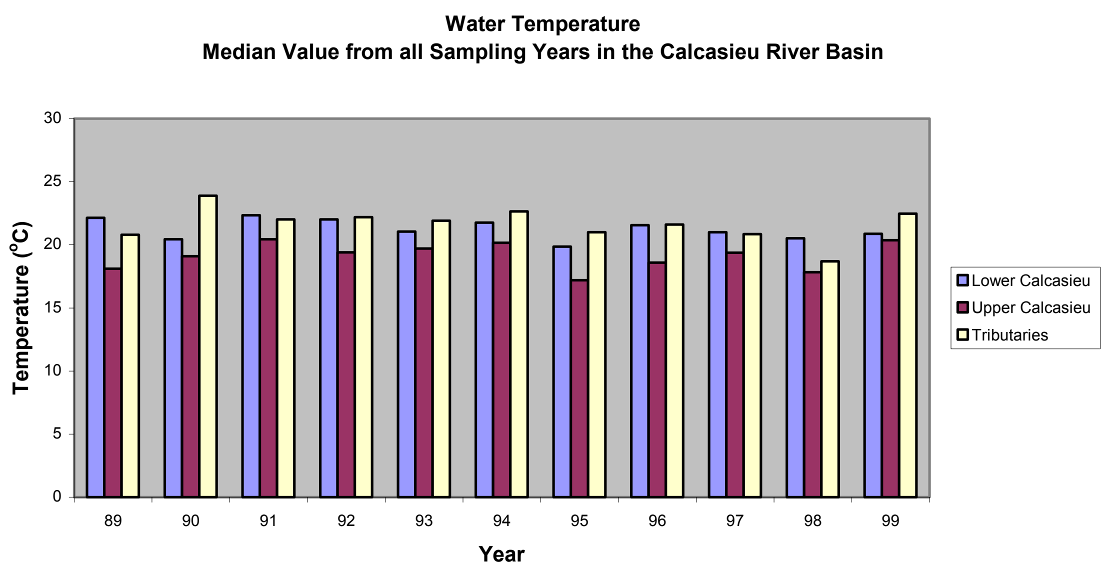
Total Suspended Solids (TSS)
Median Values from all Sampling Years in the Calcasieu River Basin



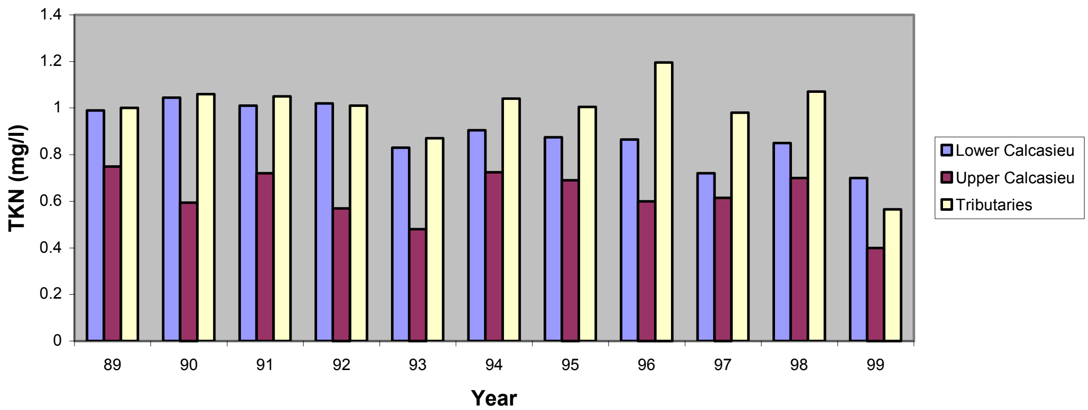
Secchi Disk
Median Value from all Sampling Years in the Calcasieu River Basin



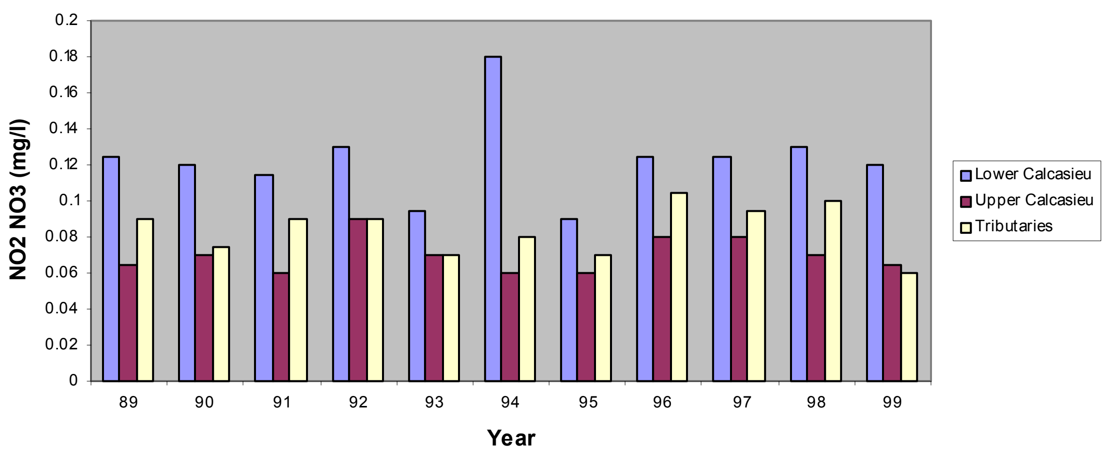

Dissolved Oxygen
Median Value from all Sampling Years in the Calcasieu River Basin
Dissolved Oxygen (mg/l)
0
1
2
3
4
5
6
7
8
9
89
90
91
92
93
94
95
96
97
98
99
Year
Lower Calcasieu
Upper Calcasieu
Tributaries

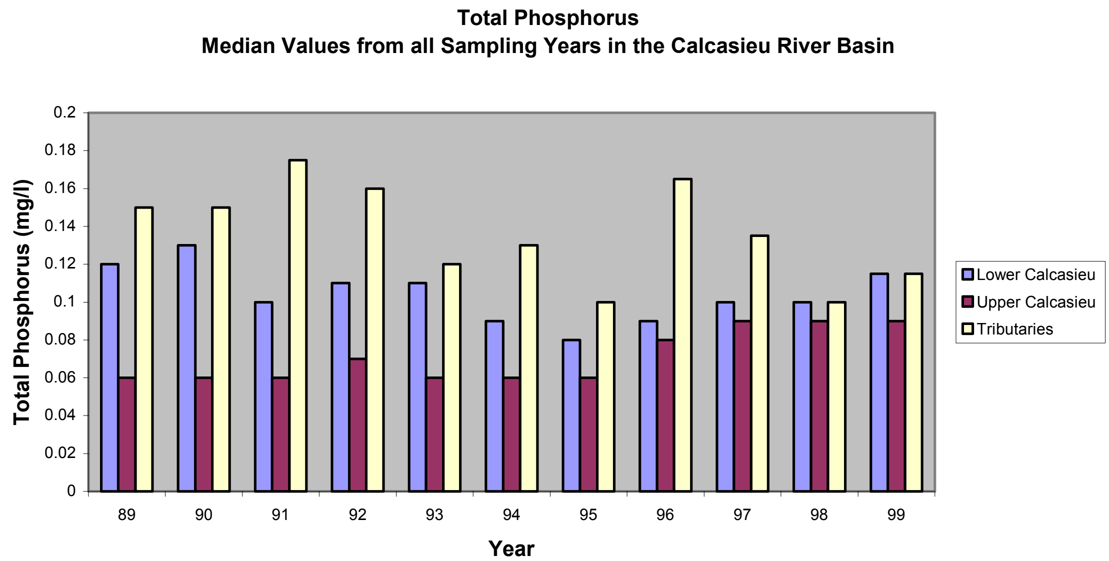

Water Temperature
Median Value from all Sampling Years in the Calcasieu River Basin
Temperature (°C)
0
5
10
15
20
25
30
89
90
91
92
93
94
95
96
97
98
99
Year
Lower Calcasieu
Upper Calcasieu
Tributaries

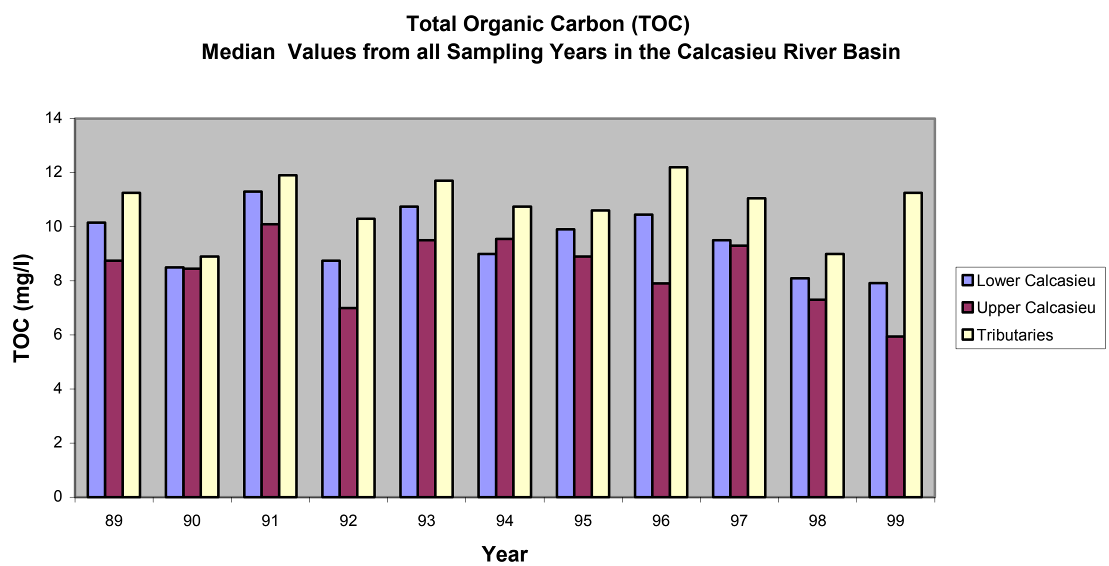
Total Kjeldahl Nitrogen (TKN)
Median Values from all Sampling Years in the Calcasieu River Basin

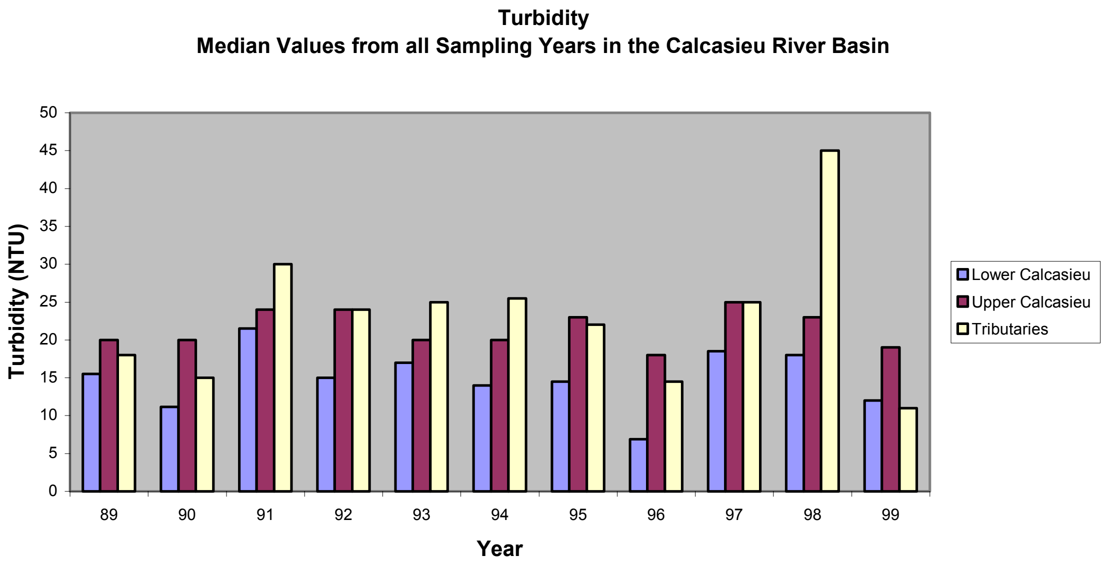


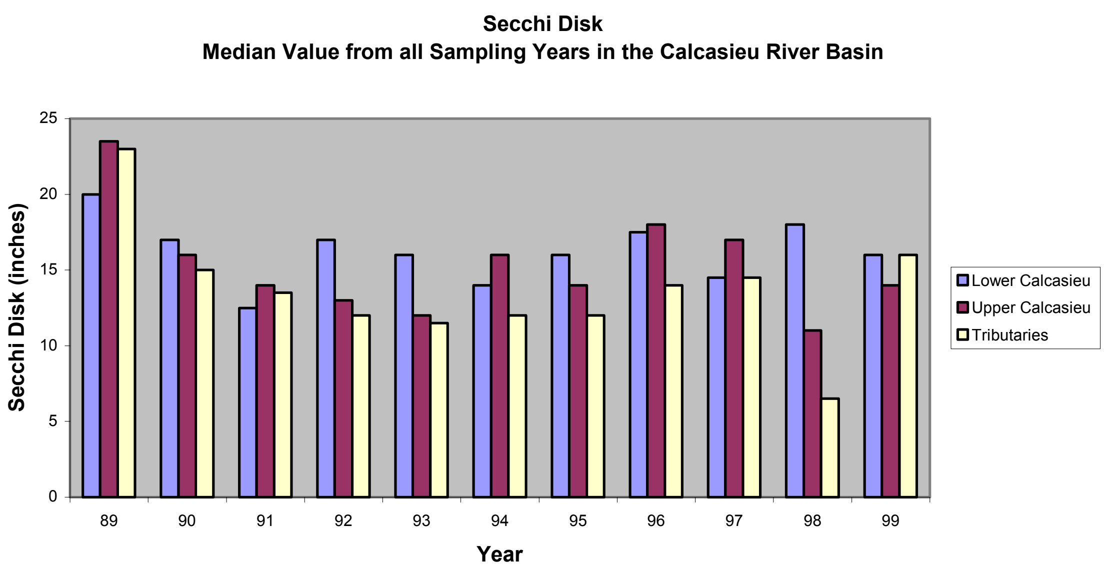
NO2 + NO3
Median from all Sampling Years in the Calcasieu River Basin

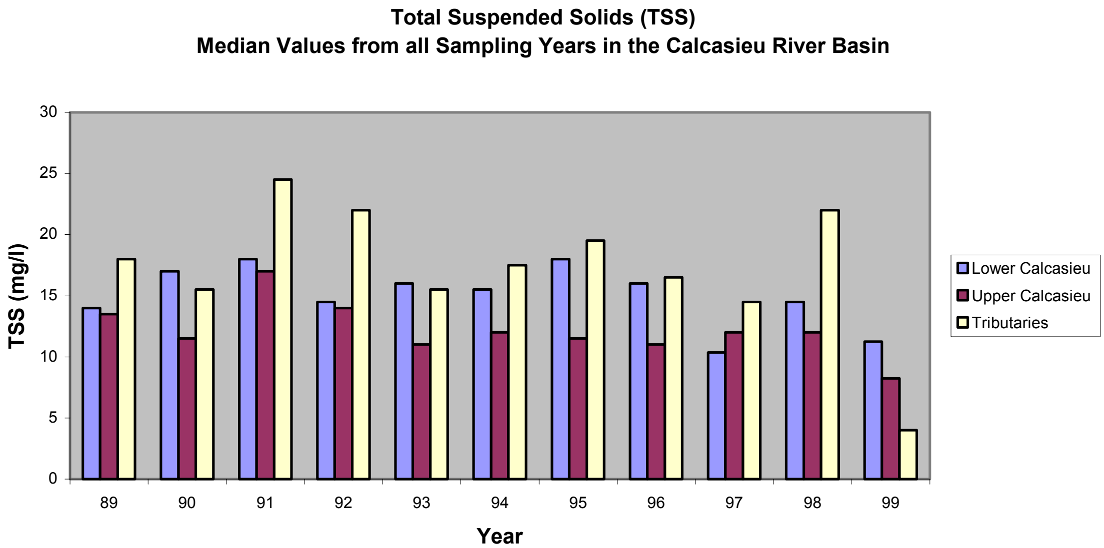


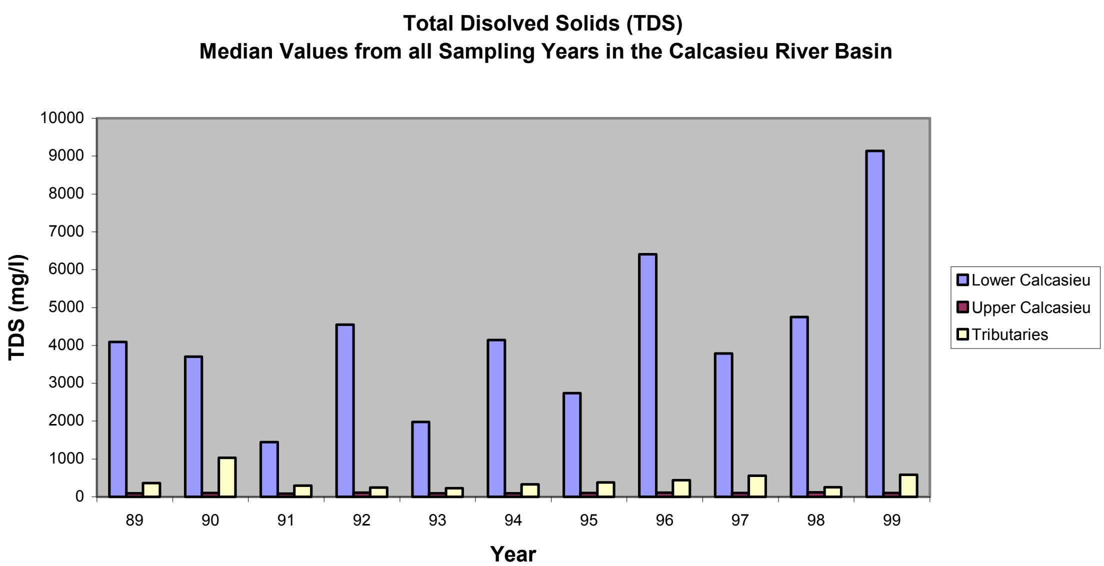

Total Phosphorus
Median Values from all Sampling Years in the Calcasieu River Basin
Total Phosphorus (mg/l)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
89
90
91
92
93
94
95
96
97
98
99
Year
Lower Calcasieu
Upper Calcasieu
Tributaries


Total Organic Carbon (TOC)
Median Values from all Sampling Years in the Calcasieu River Basin
TOC (mg/l)
14
12
10
8
6
4
2
0
89
90
91
92
93
94
95
96
97
98
99
Year
Lower Calcasieu
Upper Calcasieu
Tributaries


Turbidity
Median Values from all Sampling Years in the Calcasieu River Basin
Turbidity (NTU)
0
5
10
15
20
25
30
35
40
45
50
89
90
91
92
93
94
95
96
97
98
99
Year
Lower Calcasieu
Upper Calcasieu
Tributaries


Secchi Disk
Median Value from all Sampling Years in the Calcasieu River Basin
Secchi Disk (inches)
0
5
10
15
20
25
89
90
91
92
93
94
95
96
97
98
99
Year
Lower Calcasieu
Upper Calcasieu
Tributaries


Total Suspended Solids (TSS)
Median Values from all Sampling Years in the Calcasieu River Basin
TSS (mg/l)
30
25
20
15
10
5
0
89
90
91
92
93
94
95
96
97
98
99
Year
Lower Calcasieu
Upper Calcasieu
Tributaries


Total Disolved Solids (TDS)
Median Values from all Sampling Years in the Calcasieu River Basin
TDS (mg/l)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
89
90
91
92
93
94
95
96
97
98
99
Year
Lower Calcasieu
Upper Calcasieu
Tributaries

APPENDIX 2

Agriculture BMP References

Baffaut, C., Nearing, M.A., Nicks, A.D. 1995. Impact of Cligen Parameters on Wepp-Predicted Average Annual Soil Loss. Transactions of the ASAE. American Society of Agricultural Engineers.Vol.39(2): pp.447-457.

Bagwell, R.D., Holman, M.E., Padgett, G.B. 1999. Harvest Aids for Cotton In Louisiana. Louisiana State University Agricultural Center. Pub.2291(5.5M)

Baldwin, J.L., Boethel, D.J., Leonard, Roger. 2000. Control Soybean Insects 2000. Louisiana State University Ag. Center Research and Extension.

Baldwin, J.L., Riley, T. J., Leonard, Roger. 1999.Managing Corn and Grain Sorghum Insect Pests 2000. Louisiana Cooperative Extension Service. Louisiana State University Agricultural Center.

Ball-Coelho, B., Tissen, H., Stewart, J.W.B., Salecdo, I.H., Sampaio, V.S.B. 1993. Residue management Effects on Sugarcane Yield and Soil Properties in Northeastern Brazil. Agronomy Journal. Vol. 85. Pp.1004-1008.

Barnett, J., Boquet, D., Leonard, R., Wolcott, M. 2000. Cotton Varieties for Louisiana 2000. Louisiana State University Agricultural Center. Pub.2135(8M).

Bengtson, R.L., Selim, H.M., Ricaud, R. 1997. Water Quality from Sugarcane Production on Alluvial Soils. Transactions of the ASAE. American Society of Agricultural Engineers. Vol.4(5) pp.1331-1336.

Berger, W.C. Jr., Carney, J., Duerr, R.K. 1999. Bayou Plaquemine Brule Watershed TDML for Dissolved Oxygen Including Eight Point Source Wasteload Allocations and A Watershed Nonpoint Source Load Allocations.Vol.1&2. Subsegment 0502.

Board, J.E., Harville, B.G. 1993. Soybean Yield Component Responses to a Light Interception Gradient during the Reproductive Period. Crop Science Vol.33(4) p.772-777.

Bollich, P.K., Feagley, S.E., Gambrell, R.P., Groth, D.E. 1996. Mermentau River basin Nonpoint Source Project. Phase II Proposal. Influence of Tillage Practices on Rice Field Floodwater Quality.

Brown, L.C., Norton, L.D. Surface Residue Effects on Soil Erosion from Ridges of Different Soils and Formation. Transactions of the ASAE. American Society of Agricultural Engineers. Vol.37 (5) pp.1515-1524.

Brown, Lester. Chaney, C.R. 1999. 1999 Cool-Season Pasture and Forage Varieties. Louisiana Cooperative Extension Service. Louisiana State University Agricultural Center.

Brunson, Martin. 1989. Evaluation Of Rice Varieties for Double Cropping Crawfish and Rice in Southwest Louisiana. Louisiana Agricultural Experiment Station. Louisiana State University Agricultural Center.

Bui, E.N., Box, J.E. Jr. 1993. Growing Corn Root Effects on Interrill Soil Erosion. Soil Science American Journal. Vol.57 pp.1066-1070.

Caffey, H.R., Tipton, K.W. 1996. Insect Pest Management. Conservation Tillage systems for Energy Reduction. Louisiana Department of Natural Resources.Pub.8907 (5M)

Caffey, Rouse H., 1986.Growing Corn in Louisiana. Louisiana Cooperative Extension Service. Louisiana State University Agricultural Center.

Cartrer, R., Andries, J., Coburn, G. 1998. Cotton Insect Control Recommendations for the Red River Valley During 1998.Louisiana State University Agricultural Center. Pub. 2698. (2M).

Dickey, C.E., Shelton, D.P., Jasa, P.J., Peterson, T.R. 1984.Erosion from Tillage Systems Used in Soybean and Corn Residues. Transactions of the ASAE. American Society of Agricultural Engineers. Vol.28(4) pp.1124-1129.

Faw, W.F. 1999. Sugarcane Planting Recommendations and Suggestions. Louisiana State University Agricultural Center. Louisiana Cooperative Extension Service.

Funderburg, E. R., Burch, T.A. 1994. Cotton Fertilization. Louisiana Cooperative Extension Service. Louisiana State University Agricultural Center.

Funderburg, E. R., Morrison, W.C. 1998. Corn Fertilization. Louisiana Cooperative Extension Service. Louisiana State University Agricultural Center.

Funderburg, E.R., Bollich, Pat. 2000. Fertilization of Louisiana Rice. Louisiana State University Agricultural Center. Louisiana Agricultural Experiment Station.

Funderburg, E.R., Faw, W.F. 1995. Sugarcane Fertilization. Louisiana Cooperative Extension Service. Louisiana State University Agricultural Center.

Funderburg, E.R., Tidwell, E. K. 1998. Pasture Fertilization in Louisiana. Louisiana Cooperative Extension Service. Louisiana State University Agricultural Center.

Funderburg, Eddie. 1995. Soil Fertility. Conservation Tillage Systems for Energy Reduction. Louisiana State University Agricultural Center.Pub.8910(8M)

Griffen, J.L., Babcock, D.K. 1983. Response of Soybeans to Planting Date in Southwest Louisiana. Louisiana Agricultural Experiment Station. Louisiana State University Agricultural Center.

Harville, B.G., Snow, J.P. 1989 Louisiana Soybean Performance Trials, 1984-1988. Louisiana Agricultural Experiment Station. Louisiana State University Agricultural Center.

He, C., Riggs, J.F., Kang, Y.T. 1993. Integration of Geographic Information Systems and A Computer Model to Evaluate Impacts of Agricultural Runoff on Water Quality. Water Resources Bulletin. American Water Resources Association. Vol.29(6) pp.891-900.

Hutchinson R.L. 1995. Cotton Stand Establishment. Louisiana State University Agricultural Center. Conservation Tillage Systems for Energy Reduction. Pub.8906(8M).

Kelly, S., Barnett, J.W., Micinski, S. 2000. Cotton Insect Control 2000. Louisiana State University Agriculture Center. Pub.1083(6M).

Lee, J.J., Philips, D.L., Dodson, R.F., 1996. Sensitivity of the US Corn Belt to Climate Change and Elevated CO2: II. Soil Erosion and Organic Carbon. Agricultural Systems.52 (1996) pp. 503-521.

Lencse, R. J., Miller, D. K. 1999 Controlling Weeds in Cotton. Louisiana Cooperative Extension Service. Louisiana State University Agricultural Center.

Lencse, Reed. Faw, Wade. 1998. Controlling Weeds in Sugarcane. Louisiana Cooperative Extension Service. Louisiana State University Agricultural Center.

Lindau, C.W., Delaune, R.D., Alford, D.P. 1996. Monitoring Nitrogen Pollution From Sugarcane Runoff Using 15N Analysis. Water, Soil and Air Pollution. Vol. 89. Pp. 389-399.

Louisiana Department of Environmental Quality. 1987. Waste Load Allocation for the Vermillion River. Intensive Survey and Ancillary Data. Appendix B. Vol.3.

Martz, L.W., Garbrecht, J. Automated Extraction of Drainage network and Watershed Data from Digital Elevation Models. Water Resources Bulletin. American Water Resources Association. Vol.29(6) pp.901-908.

McClain, W.R., Bollich, P.K., Gillespie, J.M. 1997. Relaying: An Intercropping Approach to the Co-Culture of Crawfish and Rice. Louisiana State University Agriculture Center. Louisiana Agricultural Experiment Station.

Millhollon, E.P., Melville, D.R. 1991. The Long-term Effects of Winter Cover Crops on Cotton Production in Northwest Louisiana. Louisiana State University Agricultural Center. Louisiana Agricultural Experiment Station.

Morrison, Walter C., 1983. Grain Sorghum in Louisiana. Louisiana Cooperative Extension Service. Louisiana State University Agricultural Center.

Morrison, Walter. Morgan, Donna. Anderson, Rusty. 2000. Soybean Variety Recommendations and Production Tips. Louisiana State University Ag. Center Research and Extension.

N.R.C.S. 1995. Revised Universal Soil Loss Equation. Technical Guide, Notice#153. Alexandria, La.

NG Kee Kwong, K.F., Deville, J. 1993. The Course of Fertilizer Nitrogen Uptake by Rainfed Sugarcane in Mauritius. Journal of Agriculture Science. (1994) Vol.122. pp.385-391.

Orellana, F.X. (1992). Characterization of Effluents from Commercial Crawfish Ponds in South Louisiana. A Thesis. Louisiana State University, M.Sc. The School of Forestry, Wildlife, and Fisheries.

Overstreet, Charles. Berggren, G.T.1981. The Soybean Cyst Nematode In Louisiana.

Renard, K.G., G.R. Foster, G.A. Weesies, D.K. McCool, And D.C. Yoder coordinators. 1997. Predicting soil erosion by Water: A guide to Conservation Planning With the Revised Universal Soil Loss Equation(RUSLE). U.S. Department of Agriculture, Agriculture Handbook No. 703, 404 pp.

Renolds, D.B., Rogers, L.R., 1995. Preplant Weed Control in Cotton. Louisiana State University Agricultural Center. Conservation Tillage Systems for Energy Reduction. Pub.8909(8M).

Ricaud, R., Landry, G. 1976. Effects of Rate of Planting on Yield and Some Yield Components of Sugarcane. Louisiana State University and Agricultural College. Center for Agricultural Sciences and Rural Development.

Savabi, M.R., Scott, D.E. 1994. Plant Residue Impact on Rainfall Interception. Transactions of the ASAE. 1994 American Society of Agricultural Engineers. Vol. 37(4): pp. 1093-1098.

Semenzato, R. A Stimulation Study of Sugar Cane Harvesting.1994. Agricultural Systems. Vol. 47. Pp. 427-437.

Southwick, L.M., Willis, G.H., Johnson, D.C., Selim, J.M. 1994. Leaching of nitrate, Atrazine, and Metribuzin from Sugarcane in Southern Louisiana. Journal of Environmental Quality. Vol.24. pp.684-690.

Tidwell, E.K., Redfern, D.D. 1997. Forage Testing: Why, What and How. Louisiana Cooperative Extension Service. Louisiana State University Agricultural Center.

Tidwell, Ed. Brown L.P. 1999. 1999 Recommended Wheat and Oat Varieties and Management practices. Louisiana Cooperative Extension Service. Louisiana State University Agricultural Center.

Vidrene, Roy., Millhollon, E.P. 1999. Control Weeds In Soybeans. Louisiana Cooperative Extension Service. Louisiana State University Agricultural Center.

Zhang, X.C., Nearing, M.A., Risse, L.M., McGregor, K.C. 1996. Evaluation of WEPP Runoff and Soil Loss Predictions Using Natural Runoff Plot Data. Transactions of the ASAE. American Society of Agricultural Engineers. Vol.39(3) pp.855-863.